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*Full Length Research Paper*

# **Drivers and socioeconomic factors influencing individual and household adaptation to climate change: A case study of residents of Leeds, UK**

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**The dynamic nature of human adaptation and coping strategies to climate change continues to arouse the interest of environmental researchers. This study contributed to this growing area of research by examining the drivers and some socioeconomic factors influencing individual and household adaptation to climate change. Data were collected through household surveys and in-depth interviews. Descriptive statistics, binomial logistic regression, multiple regression analysis, and content/discourse analysis were employed to analyse data collected. The study result shows that the majority of the respondents adopt low cost and low skill coping responses against cold spell. The comfort of the household was found to be the key driver of adaptation to cold spell. Meanwhile, government support and having previous experience of flooding increases the chances of households adopting flood defense measures. The result further shows that house type ( $p < 0.01$ ), house ownership ( $p < 0.01$ ), and income ( $p < 0.05$ ) were significant factors affecting the level of adaptation strategies adopted. Age, gender, and education were found not to be significant in affecting the level of adaptation strategies adopted. The study recommended that government support as well as improvement in some socioeconomic factors like income level and educational level will increase individual and household resilience against climate change.**

**Key words:** Climate change, adaptation drivers, protection motivation, coping responses, individual and household, UK.

## **INTRODUCTION**

In recent years, climate change adaptation (CCA) has become the watch word in many international organizations and development agencies- such as the United Nations (UN), the Economic Co-operation and Development (OECD), etc. The focus on CCA reached a

high point perhaps with the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, and the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 (Mitchell and Tanner, 2006). These global environmental agencies,

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undoubtedly, emerged because of the need to chart a course on how the human society can cope and adapt to the vagaries of weather caused by the unprecedented rate of increase in climate change (CC) in recent human history (IPCC, 2001; UNFCCC, 1992). Accordingly, concerted efforts have been made, and researches conducted, on how to improve societal adaptive capacities (Conde et al., 2007). However, according to Porter et al. (2014), most of these efforts and researches have focused on public and private organizations with little attention to individual and household adaptation. Although climate change is a global phenomenon, its impacts are felt at the household and individual level. The UK has experienced several impacts of climate change in the recent past that necessitates individual responses. For instance, in 2013, The Climate Reality Project reported that UK and most countries in mainland Europe witnessed one of the highest heat waves in its history. This extreme climatic event which happens to be the hottest summer recorded in the last 500 years led to the death of many, with UK alone recording more than 2,000 casualties. A post assessment of this tragic event shows that individuals were not sufficiently prepared to positively respond to such extreme climatic event ((Herring et al., 2016). Another extreme climatic event in the UK that requires individual adaptation is the problem of flooding. Environmental reports in the UK show that flooding risk is on the increase (Alexander et al., 2016). In 2015, Leeds City in the UK experienced one of its highest and widespread flooding ever recorded, with a devastating effect on lives, homes, and businesses. Again, such common extreme climatic event requires adequate adaptation responses from individuals and households. An empirical examination of the proximate and underlying drivers of individual and household adaptation is the focus of this study. This is because, the little available literature on individual and household adaptation has been more theoretical, with limited empirical evidence to support a more general and representative data on individual and household engagement in CCA (Porter et al., 2014).

In the UK, progress has been made to engage the government, the public and private business companies in CCA policies. What remains is to take a step further to engage individuals and households as well (Tompkins and Adger, 2003). Available literature suggests that building CCA capacity at the individual and household levels will improve UK's resilience to CC (Shaw et al., 2007). While the roles and importance of individuals and households has been recognised in UK's Climate Impacts Programme (UKCP), empirical evidence on the key drivers, and the influence of socioeconomic factors in CCA is largely absent in the literature. This partly suggests why CCA studies grounded in UK have failed to provide solutions to major impacts of CC frequently experienced in the UK- such as cold spells and flooding. Hence the needs to critically examine the drivers and

socioeconomic factors influencing individual and household adaptation suggest a critical research agenda for UK.

According to Gawel et al. (2012), drivers of CCA are incentives that motivate individuals to respond to climatic risks. Porter et al. (2014) identified three drivers of household adaptation in the UK. These include; previous exposure to extreme weather, social acceptability, and long-term financial reward. For instance, Walker et al. (2011) and Whitmarsh (2008) found that individual households in UK who have experienced flooding show more willingness to adopt flood defense measures than households that have not experienced flooding. Furthermore, Porter et al. (2014), Stenek et al. (2013), Fankhauser and Burton (2011), and Kunreuther and Kerjan (2009) all posit that individuals and households would be more willing to adapt if they perceive the long term financial benefit of adaptation. Additionally, Grothmann and Patt (2003), in trying to find out why some individuals have more adaptive capacity than others, identified "self- motivation" and desire for comfort as another major drivers of adaptation that have been neglected in literature. They showed that often at times, people are self -motivated to take precautionary measures to protect themselves against climatic risks, as well as install adaptation features that will make their houses more comfortable, without necessarily having an external motivation.

Agrawal (2008) argues that if adaptation to CC is to help the most vulnerable social groups, then it must involve individuals at the local level, and its effectiveness depends (among other things) on building individual capacities, and understanding the key drivers and socioeconomic factors influencing their choices of adaptation strategies. UKCIP (2004) noted that CCA do not take place in isolation, it happens within the context of society, shaped by socioeconomic scenarios. Hence, capacity to adapt will be influenced by socioeconomic factors. Understanding socioeconomic variables that influence level of adaptation will therefore provide policy makers with background information about the capacity of individuals and households to build resilience to CC (Smit et al., 2007).

In the light of the above, Porter et al. (2014) classified CCA into low cost-and-low skill adaptation measures called coping responses,- meant to manage short-term climatic stimuli such as cold spells. They include mostly behavioral adjustments such as change of clothing, use of heater during winter, installing of double-glazed windows to cushion extreme colds, etc. The other class of adaptation is the more technical and financially demanding measures usually associated with adaptation with flooding. They include removing tarmac/pavement and replacing with soil/trees, taking flood insurance policy, sealing entry points to prevent water coming into the house, etc.

This study asks; do socioeconomic factors influence

the level of CCA, and what are the key drivers that motivate the adoption of various coping responses and adaptation features/strategies against cold spells and flooding? The overarching aim is to derive context-specific evidence on the drivers and socioeconomic factors influencing individual and household adaptations, using residents of Leeds as a case study. Specifically, the study seeks to: i) identify coping responses and adaptation features/strategies adopted by residents of Leeds against cold spells and flooding, ii) identify the proximate and underlying drivers of individual and household adaptation, and iii) determine socioeconomic factors affecting level of adaptation to CC.

## **THEORETICAL AND EMPIRICAL BACKGROUND**

This section presents a review of two major issues: first, it provides the theoretical underpinnings of the study; and secondly, it explores empirical literature regarding climate change adaptation and adaptation drivers. These two reviews provide a conceptual background for the study.

### **Motivation and behaviour theories**

Addressing the global challenges of climate change adaptation all relate back to individual behaviour and responses towards the environment. Human behaviour is notoriously complex and motivation for behaviour is multifaceted (Kissinger et al., 2012). In the context of climate change adaptation, several theories have been propounded to explain the motivating drivers of choosing one adaptation strategy or the other. Some of these theories have attempted to answer questions such as; how can individuals be motivated towards pro-environmental behaviour in terms of choosing the right adaptation options? What are the different strategies to influence pro environmental behavioural change?

From the wealth of several theories attempting to explain the drivers and motivations for climate change adaptation behaviour, we selected two that are most relevant to individual and household adaptation. These include the Protection Motivation Theory (PMT) and the Theory of Planned Behaviour (TPB). These are theories that link one's belief and eventual behaviours towards an issue. They are adapted to examine the role of information and environmental awareness, social interactions, and personal perceptions in influencing individual's adoption of coping/adaptation strategies thus, making them the most relevant for the study in examining the motivating drivers of climate change adaptation among individuals and households.

#### ***Protection motivation theory***

Propounded by Rogers in 1975, this theory was originally

proposed to understand fear appeals and its coping strategies (Rogers, 1975). However, in 1983 the theory was expanded to explain the concept of persuasive communication and how people behave and cope during stressful conditions (Rogers, 1983). The core assumption of the theory is that people will normally protect themselves against four perceptions: perceived probability of the occurrence of a threatening event or vulnerability; perceived severity of such a threatening event; perceived self-efficacy in managing such a threatening event; and finally perceived efficacy of recommended preventive measures (Rogers, 1983).

This theory aptly fits into explanations around how people respond to climate change threats and coping strategies against such threats. This is because the protection motivation theory anchors on two factors: threat appraisal and coping appraisal. In the climate change discourse, the threat appraisal assesses the severity of the climate change event and its adverse impacts. It takes care of the first two perceptions that people will normally protect themselves against – perceived occurrence/vulnerability and perceived severity of such occurrence. Here, the theory posits that self defence against potential threats is the motivation for certain behavioural responses. The coping appraisal on the other hand assesses how individuals respond to such situations. In this case, it assesses the last two individual's perceptions of self-efficacy and recommended efficacy of preventive measures. Self-efficacy is the belief in one's ability to cope with threatening climatic events and successfully execute recommended adaptation options (Prentice-Dunn et al., 2009). This implies that it is more likely that an individual will positively respond to or adopt coping strategies if he believes that he has the capacity and resources to execute such a coping strategy. This relates directly with the perceived resilience level of individuals against climatic threats. It also implies that costly coping strategies are less likely to be adopted by individuals. Another factor that will influence adoption of a coping strategy is the individual's expectancy and belief in the effectiveness of a recommended coping strategy to remove a climatic threat. Therefore, the PMT is one model that could be adopted to explain why individuals accept or reject some coping/adaptation strategies (Herath and Rao, 2009). It goes further to suggest ways through which negative response/behaviour towards climate change adaptation could be changed. One of such ways is the role of education and motivation in changing peoples' attitude towards climate change adaptation (Ifinedo, 2012).

#### ***Theory of planned behaviour***

The Theory of Planned Behaviour (TPB) proposed by Icek Ajzen is a modification and improvement of the Theory of Reasoned Action (TRA) – which postulates that

an individual's behaviour is usually influenced not only by his pre-existing attitudes, but also by the expected potential outcome of his behaviour (Ajzen, 1991; Ajzen and Fishbein, 1980). As an extension of the TRA, TBP, in addition to attitudes and expected behavioural outcomes incorporates perceived behavioural control (rational thinking) as factors that govern individual's considerations, which in turn influence their choices, decisions, behavioural intentions, and behaviour. The core assumption of the theory is that individual's personal attitude, subjective norms, and perceived behavioural control all come together to shape an individual's intentions and final behaviour (Ajzen and Fishbein, 1980).

According to the theory, individual's attitudes will usually be influenced by cognitive beliefs which in turn affects one's intention to act or not to act. Where the outcomes of such intentions are favourably perceived, it will most likely lead to positive behaviour and increased likelihood of actual performance. This suggests a nexus between attitudes, intentions and behaviour. Some environmental scholars have hinged on this to posit that most pro- environmental behaviours are as a result of self- motivation (internal factors) that results from one's perceived benefit of adopting one adaptation strategy or not (Grothmann and Patt, 2003).

In a similar manner, intentions and final behaviour are not only products of beliefs and attitudes but also influenced by subjective norms. This is against the backdrop that man is a social being and thus, his behaviour and actions will be influenced by the beliefs and actions of others. This suggests that in a situation where the general society demonstrates a favourable response towards an issue, individuals are most likely to key it to the societal thinking and consequently develop a similar positive behaviour towards such an issue. This could further explain the upsurge of positive interests about climate change adaptation in the society today. Many people are gradually becoming interested in climate change adaptation as a result of public awareness campaign and global interest on the matter (Ford et al., 2011; Wolf et al., 2010; Parry et al., 2009).

The third distinguishing component of the TPB is the perceived behavioural control which influences one's intentions and behaviour. This has to do with one's perceived ability to actually perform or engage in a particular behaviour. Available literature on TPB shows that this perception is divided into internal and external

control factors. The internal controls relates to how an individual perceives himself as being in control of a specific behaviour. Such level of control, according to Jackson (2005), is usually influenced by the sufficiency of the resources available to him such as skills, finance, and knowledge, in addition to the amount of sacrifice or discipline he is willing to make in performing the behavior. The level of climate change knowledge and awareness, together with the amount of information availability about a particular adaptation strategy comes to play here in determining adaptation responses and drivers. Modern proponents of this theory have however acknowledged that the link between information availability, intention to act and final behaviour is not very straightforward; there are other intervening factors between awareness, intention and behaviour (Kaiser et al., 2010; Jackson, 2005; Kollmuss and Agyeman, 2002). For example, level of understanding a particular adaptation strategy will ultimately influence final behaviour in adoption. External controls on the other hand more or less mirror the influence of subjective norms. It relates to how societal perceptions, acceptance or approval of behaviour will influence individual's action towards such behaviour. For example, if one's family and/or friends approve or are practicing a particular adaptation strategy, it may boost an individual's intention to adopt such strategy. In addition to societal perception, time is another factor that will impact behavioural control. The following section explores relevant empirical evidences on individual and household adaptation and adaptation drivers to climate change.

### **Empirical evidence on what we know about types and drivers of individual and household adaptation to climate change**

#### ***Types of climate change adaptation***

Available literature identifies different types of adaptation. According to Carter et al. (1994), there are many factors that determine how adaptation is classified. These factors include; time of response, spontaneity of response, and level of engagement (Porter et al., 2014; IPCC, 2001; Smit et al., 2000; Burton, 2000). Based on these factors, the following adaptation types were identified:

Reactive adaptation	}	Based on time of response
Anticipatory adaptation		
Autonomous adaptation	}	Based on spontaneity of response
Planned adaptation		
Private adaptation	}	Based on level of engagement
Public adaptation		

IPCC (2001) defined reactive adaptation as any

adaptation that takes place after the impacts of CC have

been observed. Porter et al. (2014) noted that most individual and household adaptation types in the UK fall within this category. This assertion was supported by New et al. (2011) and Ford et al. (2011) who found out that most households in UK only adopted some flood defence measures after experiencing flooding. On the other hand, anticipatory adaptations are adaptations that require more proactive approach such as construction of storage reservoirs to guard against flooding (IPCC, 2001). Harvatt et al. (2011) disclosed that most UK residents are not sensitive to this type of adaptation. It was discovered that reactive adaptation has a direct link with “private adaptation” type which is any adaptation initiated by individuals (IPCC, 2001). However, private and reactive response actions are grossly inadequate to manage more complex and serious climate risks (Niemeyer et al., 2005).

Autonomous adaptation which does not require any conscious planning (IPCC, 2001) is more common in responding to ‘short term’ climatic stimuli (example cold spells, heat stress) among individual households (Harvatt et al. 2011). This is what Porter et al. (2014) termed “*Coping responses*”. According to them, coping responses are less expensive actions to manage short-term climatic stimuli. They include mostly behavioral adjustments such as change of clothing, use of heater during winter, installing of double-glazed windows to cushion extreme colds etc. (Porter et al., 2014). Planned adaptation on the other hand requires premeditated deliberate strategy to respond to climatic stimuli (IPCC, 2001). Harvatt et al. (2011) linked this type of adaptation to ‘long term’ climatic risks such as flooding. Porter et al. (2014) noted that adaptations of this type are more costly, more challenging, and more complex, requiring greater technical investments. Unfortunately, Porter et al. (2014), Harvatt et al. (2011), and Paavola and Adger (2005) revealed that most individual/households in UK are not willing to respond to this type of adaptation without any form of government support. This implies that planned adaptation is related to public adaptation, which are adaptations normally initiated by the government.

### ***Drivers of climate change adaptation***

Drivers of climate change adaptation are incentives that motivate individuals to respond to climatic risks (Gawel et al., 2012). Porter et al. (2014) identified three drivers of household adaptation in the UK. These include; previous exposure to extreme weather, social acceptability, and long-term financial reward”. The paper explained that individual households who have experienced any form of environmental disaster are more likely to respond to climatic stimuli more than those that have not. This finding was supported by Walker et al. (2011) and Whitmarsh (2008) who noted that individual households in UK who have experienced flooding show more

willingness to adopt flood defence measures than households that have not experienced flooding.

On the issue of social acceptability as a driver of adaptation, there are supporting and opposing evidences. For example, Adger (2003) demonstrated that in the events of extreme cold weather, social acceptable measures could influence households’ choice of adaptation. This assertion was reinforced by Kent et al. (2013) who noted that during winter, it is a common practice in UK for people to turn on the heater to keep the house warm for visitors. However, Wolf et al. (2010) provided contrary evidence with the claim that social acceptability could worsen vulnerability, especially in the event of hot weather. They supported their claim with the finding that most elderly people in UK did not consider heat wave as a serious climatic risk that requires adaptation, as such, they perceived social acceptable measures such as social bonding/networks as a detrimental measure that could exacerbate vulnerability. This argument seems to suggest that while social acceptable measures may be useful in influencing adaptation options against extreme cold weather, it may be less functional in building coping strategies against extreme hot weather.

Concerning the third driver of adaptation, Porter et al. (2014) and Kunreuther and Kerjan (2009) noted that individuals and households would be more willing to adapt if they perceive the long term financial benefit of adaptation. According to Stenek et al. (2013), house owners in UK who have either taken flood insurance policies or install flood preventive features are those who believe that in the long run, these features will pay off by reducing their costs of adapting to climate change consequences such as flooding. This, according to Fankhauser and Burton (2011), are individuals who believe that it is cheaper to take preventive measures than to pay for havocs of climatic risks. There are other drivers of adaptation that have not been explored very well in the literature. For instance, Grothmann and Patt (2003), in trying to find out why some individuals have more adaptive capacity than others, identified “self-motivation” and “perceived ability” as another major driver of adaptation that have been neglected in literature. They showed that often at times, people are self-motivated to take precautionary measures to protect themselves against climatic risks, without necessarily having an external motivation.

## **METHODOLOGY**

### **Sampling procedure and data collection**

The study area is Leeds, UK, which has experienced some extreme climatic events like flooding, cold spell, and heat waves in the recent past. The study engaged a mixed methods approach where quantitative method (survey) was combined with context specific qualitative method (in-depth interviews). Both methods have their strengths and weaknesses. While the quantitative method is very

**Table 1.** Sample distribution.

England population (census)	Study sample (%)	Number of persons interviewed	
<b>Gender</b>			
49.1% males	50	245 persons	
50.9% females	50	245 persons	
<b>Age</b>			<b>For in-depth interview</b>
49% 18 – 44 years old	50	245 persons	5 persons
31% 45 – 64 years old	30	147 persons	5 persons
20% 65 or over years old	20	98 persons	5 persons

useful in generalising results, it tends to oversimplify reality. The qualitative method on the other hand is very apt in critically analysing reality through the provision of “deep and rich observational” data, but however lacks the quality of generalisability (O’Leary, 2005). Thus, the mixed method approach was employed to help overcome the weaknesses of the two whilst drawing on their strengths.

For quantitative method, semi-structure questionnaires were administered to 490 individuals/households to elicit data on coping responses and adaptation features/strategies, socioeconomic characteristics, and drivers of CC adaptation. Non-probability (quota) sampling was employed based on the England population distribution. The quota was based on two observed characteristics of the population— gender and age according to the England population census (Table1). The individuals within these groups were interviewed until the quota was met. The quota approach was employed in this study because it ensured that the individuals interviewed were fairly distributed among the study population in order to enhance unbiased representation of the perceptions and experiences across various groups (O’Leary, 2005).

The quantitative survey data were complemented with 15 in-depth interviews selected from the 490 sampled respondents using quota sampling (5 from each of the 3 age category in Table 1). The discussions were organised using an interview guide which was structured to elicit information about the individual/household’s adaptive measures and motivations for such actions. Specifically, the in-depth interview served triangulation purpose by deepening the understanding about drivers of CCA and unpacking the reasons/motivations behind their choices of adaptation measures. In other words, in-depth interview aimed to improve the reliability of the quantitative model on drivers of CCA.

### Data analysis

The choice of analytical tools was guided by the specific objectives and the nature of data collected. Data on adopted coping responses and adaptation strategies in objective one were analysed using descriptive statistics of frequency and percentages. A combination of binomial logistic regression (BLR) and content/discourse analysis were employed to analyse the proximate and underlying drivers of individual and household adaptation in objective two. Multiple linear regression analysis was employed to determine socioeconomic factors affecting level CCA in objective three.

### Model specification

#### *Binomial logistic regression*

BLR was employed to ascertain the factors that drive the adoption

of three most popular adaptation strategies against cold spells and flooding. BLR was employed because it is widely used where the dependent variable is a dichotomous (or dummy variable) with two possible outcomes. The regression model predicted the logit, that is, the natural log of the odds of adopting one adaptation strategy (yes) or not (No). The model can be represented as follows:

$$\ln(\text{ODDS}) = \left[ \frac{\hat{Y}}{1 - \hat{Y}} \right] = a + bx_1 + bx_2 + bx_3 + bx_4 + bx_5 \quad (1)$$

Where  $\hat{Y}$  is the predicted probability of adopting an adaptation feature, which is coded 1 for Yes.  $1 - \hat{Y}$  is the predicted probability of not adopting a particular adaptation strategy, coded 0 for No. ‘a’ is the constant, ‘b’ is the coefficient of predictor variables, while ‘ $X_1 - X_5$ ’ represents our predictor variables, in this case, drivers of CCA (that is, to save cost, comfort, protect environment, government support, and previous experience respectively).

All the assumptions for BLR were also met. For instance, the dependent variables (that is, adaptation features) are measured in dichotomous scale (yes or no), and are mutually exclusive. Again, there was no continuous variable among the independent variables. So the assumption of linear relationship between any continuous independent variables and the logit transformation of the dependent variable was not violated. To find the parameter estimates for the model, a BLR was ran for each of the selected adaptation strategies, and the exponential of coefficient of the drivers were extracted from the result tables titled ‘variables in the equation’ and presented in Appendix Table 2.

The exponential of coefficient  $\text{Exp}(B)$  in a BLR can be interpreted in terms of the odd ration. When the odd ratio is  $>1$ , the probability of the event occurring with unit increase in the independent variable is higher than at the original value of independent variable. On the other hand, when the odd ratio is  $<1$ , the probability of the event occurring with unit increase in the independent variable is lower than at the original value of independent variable (Schüppert, 2009).

#### *Multiple linear regression analysis*

A number of modifications and tests were carried out to ensure that data satisfy certain assumptions for linear regression. First, data on the level of adaptation (dependent variable, Y) was converted from categorical to continuous variables, by adding up the number of adaptation features adopted by each respondent. Secondly, to ensure the validity of the regression result, test for normality was carried out to assess the normality of the distribution of the data as

well as other key assumptions. The kolmogorov-smirnov statistics (0.170) shows a non-significant value of 0.1300 ( $p$ -value > 0.05) which indicates that the data are normally distributed (Appendix Table 3). This was further confirmed by the scatterplot which shows a fairly clear linear relationship and histogram which followed a normal distribution (Appendix Figures 1 and 2 respectively). The function for the multiple linear regression analysis can be represented as follows:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + e \quad (2)$$

Where: Y = Dependent variable (level of adaptation strategies adopted),  $B_0$  = Intercept,  $B_1$ - $B_n$  = Coefficient of explanatory variables,  $(X_1$ - $X_n)$  = Socioeconomic factors,  $X_1$  = age of the respondent (years),  $X_2$  = annual gross income (the midpoint of each income category for each respondent was calculated, £GBP),  $X_3$  = education level of the respondent,  $X_4$  = gender (Male or female),  $X_5$  = Children (Yes or No),  $X_6$  = Household type,  $X_7$  = Household ownership,  $X_8$  = years lived in home,  $e$  = stochastic error term.

## RESULTS AND DISCUSSION

### Coping responses and adaptation measures against cold spells and flooding

Adapting to climate change requires some low-cost and low-skill measures, as well as some high-cost and technical skill measures. Various coping responses and adaptation features/strategies adopted by residents of Leeds against cold spells and flooding were investigated. The extent to which each these adaptation options were adopted in the study area is presented in Table 1. The result in Appendix Table 1 shows that majority of the respondents easily adopt low cost and low skill coping responses against cold spell. For instance, 81.6% would wear heavier clothes during cold weather while about 78.8% would keep the house warm by turning on the heater. These coping responses fall under what Porter et al. (2014) classified as coping responses. They are behavioral adjustments that require no premeditated plan; they occur spontaneously, and often take place after the impact of climate change has been experienced. This finding also agrees with Ford et al. (2011) who found that coping response actions against extreme weather events are common among UK households, and often require no government intervention to occur.

Furthermore, the adoption of some adaptation features against cold spell, such as double (or triple) glazing (90.2%), loft insulation (58.8%) show an appreciable amount of popularity among the respondents. However, the use of wood-burning stove as an adaptation measure against cold is not popular in the area. This could be attributed to the difficulty and inconvenience in sourcing, storing, and putting the wood into the chamber. Nevertheless, some previous studies have found that the use of wood-burning stove, apart from being a cheaper heating source, is also an eco-friendly strategy of adapting to cold spells (Leslie et al., 2012; Houck and

Tiegs, 1988). Although burning of wood releases carbon dioxide into the air, it actually balances the carbon cycle, because the same wood absorbed carbon from the air to grow. In contrast, man-made heating machines emit and keep a lot of carbon dioxide into the air with no absorption pathway. This suggests that although the use of wood-burning stove is unpopular in the area, it presents a relatively cheaper and eco-friendly adaptation measure that can be exploited to adapt to cold spells.

A further study of Appendix Table 1 also reveals that when it comes to more technical, financially demanding, and anticipatory adaptation measures against flooding, the percentage adoption falls drastically. For instance, while about 90.2% of the respondents installed or are willing to install double/triple glazing window in the building as an adaptation measure against cold spell, only about 3.1% are willing to remove tarmac/pavement and replace with soil/tree as an adaptation measure against flooding. This is coherent with previous findings from Harvatt et al. (2011) who found that most households in UK are not sensitive to anticipatory adaptation measures-usually associated with adaptation to flooding. In addition, the poor adoption or willingness to adopt flooding adaptation measures may not be unconnected with the findings from Porter et al. (2014), Harvatt et al. (2011), and Paavola and Adger (2005) who noted that most individuals and households in UK may not respond to adaptation against flooding without any form of government support. It can therefore be concluded from the analysis of coping responses and adaptation measures against cold spells and flooding that, while individuals and households can autonomously adapt to cold spells, some form of incentives and support may be needed to build resilience against flooding at the individual and household level.

### Drivers of individual and household adaptation

From Appendix Table 2, the odds of installing double glazing (0.206), loft insulation (0.320), and cavity insulation (0.342) are lower for those who consider saving cost in the long run as a driver of adaptation to cold spell. In other words, those who consider cost as a driver of adaptation against cold spell are 79.4, 68.0, and 65.8% less likely to double glaze, loft insulate, and install cavity insulation respectively in their houses than those who do not consider cost as a driver. This implies that cost consideration was not found to be a major driver of adaptation against cold spell in the study area. This result contradicts the findings of Porter et al. (2014) and Kunreuther and Kerjan (2009) who noted that individuals and households would be more willing to adapt if they perceive the long term financial benefit of adaptation. The same could be interpreted for other drivers such as; protecting the environment, and government support-whose odd values are less than 1. The only driver of

adaptation against cold spell that significantly influences adoption of double glazing (1.242), loft insulation (1.553), and cavity insulation (1.442) is comfort of the house, whose odd values are greater than 1.

These findings imply that most individuals and households protect themselves against cold spells primarily to make their houses more comfortable. It has been reported in the literature that people are often self-motivated to take precautionary measures to protect themselves against climatic risks, without necessarily having an external motivation (Grothmann and Patt, 2003). During the in-depth interview, comfort was also found to be the underlying reason why people adapt to cold spells. As one of the respondents puts it; *“I want to be comfortable in my house, and I will do anything to keep my house warm during winter. I have never considered cost, or the environment as a reason for installing some of the features you mentioned. I also don't think I need the government to keep my house warm, they have bigger functions to do in the society...”* (An elderly male resident in Leeds, age 68 years).

Concerning adaptation against flooding, the result shows that receiving government support, and having previous experience of flooding whether in the house or elsewhere, all of which have odd values greater than 1, will increase the chances of adopting flood defence measures such as removing tarmac, taking flood insurance, and moving electricity fixtures up wall. Porter et al. (2014), Walker et al. (2011) and Whitmarsh (2008) also made similar observations when they identified previous exposure to environmental disasters, and some form of government support as major drivers of CCA.

### **Socioeconomic factors affecting level of adoption of adaptation strategies**

Ordinary least square multiple linear regressions analysis was employed to determine socioeconomic factors affecting level of adoption of adaptation strategies. The result of the analysis is presented in Appendix Table 4. The result shows that house type and house ownership were significant at 1% level of significance, while income was significant at 5% level of significance, indicating that these variables affect the level of adaptation strategies adopted in the study area. The coefficient values in Appendix Table 4 also shows that for a unit increase in the house type and house ownership, the model predicts that the level of adaptation will increase by 0.168 and 0.180 respectively, holding all other independent variables constant. These partly imply that individuals who own their house tend to adopt more adaptation strategies than those individuals living in rented apartments. In line with the protection motivation theory, this finding confirms that individuals will normally protect themselves and their property against perceived probability of the occurrence of a threatening event or vulnerability, perceived severity of such a threatening

event, and perceived self- efficacy in managing such a threatening event. Thus, house owners are more motivated to adopt more adaptation strategies as a protective measure against their property more than tenants who have little stake or self-interest in the building.

Similarly, the type of house one lives in is likely to affect one's level of adoption of adaptation strategies. We found from our observation and interaction with respondents that individuals living in bungalows tend to adopt more adaptation strategies. This might not be unconnected with the relatively high income level of such households as against individuals living in terraced houses who mostly fall under low/middle income class (Department for Communities and Local Government, 2010; Burrows, 2003). This finding further relates with the significance of income level in affecting the level of adoption of adaptation strategies. Several authors have found that individuals with higher income are more likely to adopt more adaptation strategies, especially the more technical and financially demanding, adaptation measures (Feng et al., 2017; Mabe et al., 2014; Uddin et al., 2014). Overall, the significant relationship of these socioeconomic factors confirms the findings of Smit et al. (2007) who noted that socioeconomic status is an important factor which affects respondents' behaviour and attitudes towards CCA. Improvement in some socioeconomic status such as income will therefore increase individuals' and households' resilience to CC.

### **Conclusion**

Understanding the key drivers and socioeconomic factors influencing individual and household adaptation is a step in the right direction towards strengthening UK's resilience to CC. From the results of the study, it is obvious that government support is needed as a vital driver to increase individual and household resilience to long-term climatic risks such as flooding. Improvement in the socioeconomic status of individuals and households are also needed to strengthen CCA at the individual and household level. This, however, does not mean that socioeconomic variables and drivers identified in this study are the only factors needed to enhance individual and household engagement in CCA. More pragmatic research is recommended to further identify and/or confirm other factors, as well as barriers to CCA not covered in this study.

### **CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

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**Appendix Table 1.** Summary descriptive statistics for coping responses and adaptation measures against cold spells and flooding.

<b>Adaptation measures</b>	<b>Frequency</b>	<b>Percentage</b>
<b>Low-cost and low-skill coping responses against cold spell</b>		
Wear extra and heavier clothes		
Yes	400.0	81.6
No	90.0	18.4
Turn up or keep on for longer the heating		
Yes	386.0	78.8
No	104.0	21.2
Have more hot meals and drinks		
Yes	272.0	55.5
No	218.0	44.5
Use draft excluders		
Yes	121.0	24.7
No	369.0	75.3
<b>Adaptation features against cold spell</b>		
Double (or triple) glazing		
Yes	442	90.2
No	48	9.8
Loft insulation		
Yes	288	58.8
No	202	41.2
Cavity wall insulation		
Yes	217	44.3
No	273	55.7
Wood burning stove		
Yes	42	8.6
No	448	91.4
<b>More technical and High-cost adaptation against flooding</b>		
Removed tarmac/pavement and replaced with soil/trees		
Yes	15	3.1
No	475	96.9
Take flood insurance policy		
Yes	49	10.0
No	441	90.0
Move electricity fixtures up the wall		
Yes	16	3.3
No	474	96.7
Seal entry points to prevent water coming into the house		
Yes	38	7.8
No	452	92.2
Water-proof external walls and doors for lower ground floor		
Yes	24	4.9
No	466	95.1
Subscribed to the Environment Agency flood warning service		
Yes	21	4.3
No	469	95.7

Source: Field survey, 2016.

**Source:** Field survey, 2016.

**Appendix Table 2.** Summary Exponential of coefficient [Exp (B)] of drivers of individual and household adaptation.

Drivers	Double (triple) gazing	Loft insulation	Cavity insulation	Remove tarmac	Flood insurance	Move electricity fixtures
To save cost in the long run	0.206 (-79.4)	0.320 (-68.0)	0.342 (-65.8)	-	-	-
Comfort of the house	1.242 (24.2)	1.553 (55.3)	1.442 (44.2)	-	-	-
To protect the environment	0.998 (-0.2)	0.698 (-30.2)	0.122 (-87.8)	-	-	-
Government support	0.999 (-0.1)	0.640 (-36.0)	0.210 (-79.0)	1.001 (0.1)	1.758 (75.8)	0.990 (-1.0)
Experience flooding in house	-	-	-	1.999 (99.9)	1.246 (24.6)	1.150 (15.0)
Experience flooding elsewhere	-	-	-	1.606 (60.6)	1.245(24.5)	1.150(15.0)

The figures in bracket are probability percentage derived by:  $\text{Exp (B)} * 100 - 100$ .

**Appendix Table 3.** Normality test result.

	Tests of normality					
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Level_of_adoption_of_adaptation_strategies	0.170	490	0.130	0.965	490	0.1300

a. Lilliefors Significance Correction.

**Appendix Table 4.** Multiple regression analysis result on the socioeconomic factors affecting level of adoption of adaptation strategies.

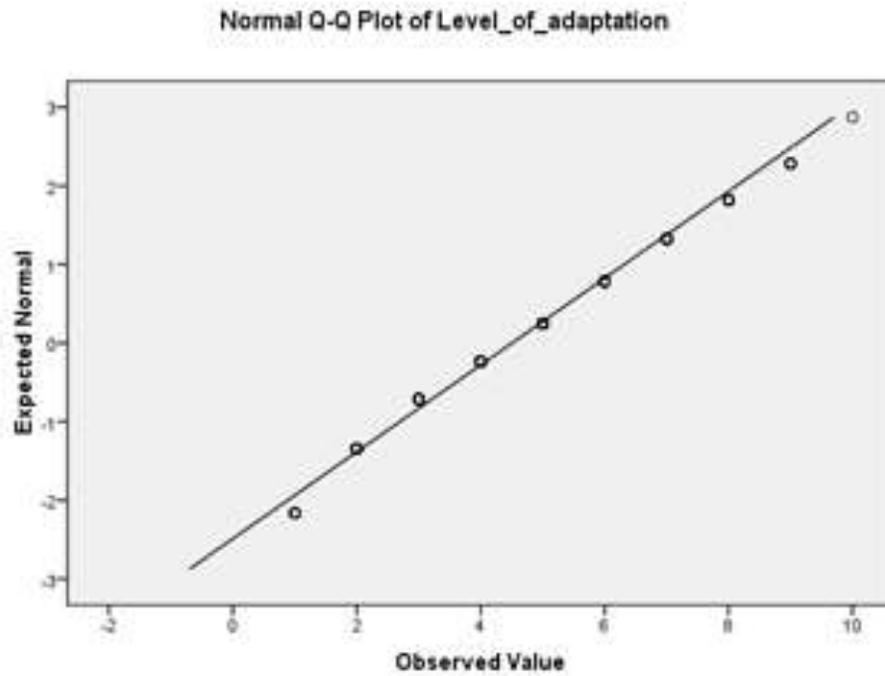
Model summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.423 <sup>a</sup>	0.179	0.165	1.654

a. Predictors: (Constant), Children, Age, Gender, Income, Education, House\_Type, House\_Ownership, Years\_lived\_in\_home

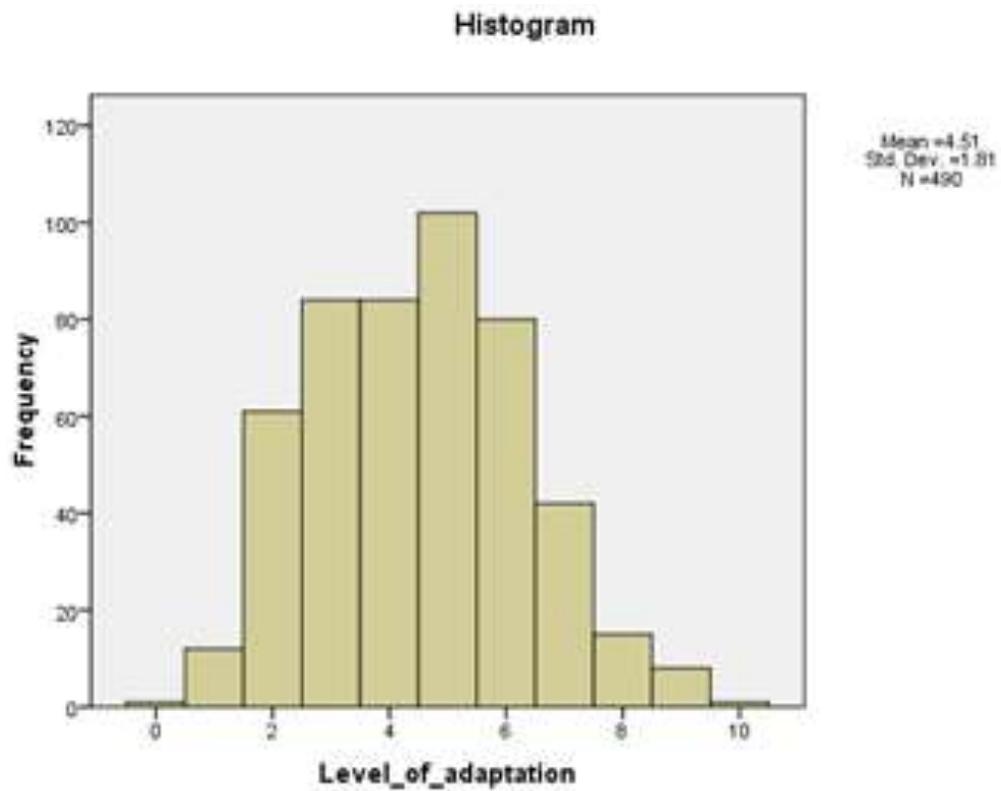
ANOVA <sup>b</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	287.050	8	35.881	13.120	0.000 <sup>a</sup>
	Residual	1315.432	481	2.735		
	Total	1602.482	489			

a. Predictors: (Constant), Children, Age, Gender, Income, Education, House\_Type, House\_Ownership, Years\_lived\_in\_home, b. Dependent Variable: Level\_of\_adoption\_of\_adaptation\_strategies

Coefficients <sup>a</sup>						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.318	0.398		5.831	0.000
	Age	0.003	0.006	0.031	0.540	0.589
	Education	0.107	0.063	0.077	1.691	0.091
	Income	0.090	0.031	0.135	2.880	0.004
	Gender	0.054	0.150	0.015	0.359	0.720
	House_Type	0.210	0.061	0.168	3.460	0.001
	House_Ownership	0.653	0.199	0.180	3.287	0.001
	Years_lived_in_home	0.011	0.008	0.074	1.332	0.183
	Children	0.108	0.174	0.026	0.624	0.533



Appendix Figure 1. Scatterplot result for normality test confirmation.



Appendix Figure 2. Histogram result for normality test confirmation.

*Full Length Research Paper*

# **Access to land and agricultural based livelihoods in Northwestern Ethiopia: Implications for land use**

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**Land has been curtail national asset and seen as central to economy, the social and political spheres of community as well as the overall society. The objective of this paper has been to assess the implication of accessing land and agricultural based livelihoods of smallholder on land use. The underpinning research involved both primary and secondary data. Primary data were generated using household surveys, focus group discussions and observations. The study revealed that unlike the northern, central highlands and southern parts of Ethiopia, access to land in the northwestern lowlands has emanated from traditional open access regimes. Here, increasing demand for land, formalization process of rural land ownership and access occurring since 2003 combined with poor soil and water conservation practices have negatively affected the productivity of land. Long-standing traditions of agricultural extensification practices coupled with shifting cultivation and open grazing have failed to remain viable strategies of smallholder farmers. Consequently, smallholder farmers have experienced unwise population induced agricultural intensification practices, resulting in decreasing land productivity. Based on the evidences from this study, it is concluded that unless proper measures are taken, the current agricultural based livelihood strategies are not in line with sustainable land use practices.**

**Key words:** Agriculture, land use, livelihood, strategy.

## **INTRODUCTION**

Land, which is the central to economy, social and political spheres of community, society and the nation at large is regarded as crucial asset. For farming households, whose livelihoods are partly or entirely dependent on agriculture and based on traditional production system, land play pivotal role (Hirut and Giovarelli, 2013) in shaping and directing livelihoods and it may cause multiple difficulties for livelihood strategies (Ellis and Allison, 2004) and utilization agricultural and natural resource management (Shimelles et al, 2009). As noted

by Espinosa (2014), land tenure is Africa's most precious and coveted asset. This is true in Ethiopia as land is in high demand and is mainstay of smallholder's livelihoods. On the other hand, livelihood activities determine the land use (Haines-Young, 2009). There are different ways of accessing land and different land suitability depending on the purpose and use of both these factors have implication on land use, land cover, livelihoods and natural resources conservation.

Ethiopia is one of the few countries in Africa that has

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not made significant changes in its basic land policy for over three decades; except for occasional land redistributions to accommodate the growing population (Samuel, 2006; Deininger et al., 2016). The long time for redistribution of land along with increasing demand for land, and the consequence of population increases, have resulted in the domination of customary land right. With regard to property rights to land, Crewett et al. (2008) identified several different property regime classification in Ethiopia including: open access (no rights defined), public (held by the state), common (held by a community or group of users), and private (held by individuals or "legal individuals" such as companies). A study conducted by Kamara et al. (2004) shows that property rights over natural resources in most of Africa originated as communal systems with households having exclusive rights to the use of croplands and shared rights plus access options to rangelands, forests and water resources. The northwestern lowlands of the Ethiopia, has a huge potential to access more cultivable land. This open access land has been unexploited until recent times.

While more usually, the land tenure system of the country operates with public ownership and usufruct right of the beneficiaries, traditional land holding systems and property regimes differ in this region and have resulted in unique land use. In addition, the landlessness is becoming the emerging challenge to rural areas, where agriculture has been the major source of livelihoods. Taking existing evidence from Sub-Saharan Africa, Ellis (2005) predicted that the next generation will not be so lucky and intergenerational tensions about the future disposition of land rights will prevail. The issue of land use and associated natural resources are becoming very pressing socio-economic problems in the study areas. Issues stem from deep rooted traditional systems of accessing land access and use combined with livelihood activities associated with nearby natural resources in these agrarian based production systems. Poor land administration systems exacerbate the situation. For agrarian communities, agricultural based livelihoods strategies and activities are functions of land and associated resources. This paper aims to shed light on agricultural based livelihoods strategies and activities of smallholders and the implication for land use.

## METHODS

The study was conducted in the northwestern lowland of Ethiopia bordering Sudan, where diverse agricultural based livelihoods strategies have been conducted. Both primary and secondary sources were exploited to generate qualitative and quantitative data. Taking households as unit of analysis, 146 households were randomly sampled from 2,786 having population of 12,903 in the district. The following techniques and tools were employed to generate data. For primary data, household surveys from randomly taken 146 households using questionnaire, focus group discussions (FGDs) of different representations of the community (21 participants in three groups) and key informant interview with

experienced individuals (3) and 2 government officials for detailed qualitative investigation were conducted. Key informant interviews and focus group discussions were administered using independent checklists. Observation of vegetation, settlement patterns, farming systems and natural resources conservation practices and housing condition were conducted by visiting different villages of the district as part of data collection process. Published and unpublished secondary data were also used to substantiate the primary data.

The quantitative data generated from primary sources were analyzed with the support of the Statistical Package for Social Sciences (SPSS) version 20. The analysis was mainly carried out using descriptive statistics including means and frequencies. Descriptions, narration and contextualization were also used to analyze the qualitative data to consolidate the quantitative results.

## RESULTS AND DISCUSSION

### Access to land and property regime

The land size and productivity per a given plot are decreasing in the study area, whereas the needs to satisfy household demand are increasing, which could be explained with fundamental economic questions about production and populations. The paradox leads to question how farm households meet their demands under limited land and declining trends productivity while ensuring sustainable land use system.

The Ethiopian land tenure system and rights has experienced different forms under various historical, economical and political circumstances. The farm households in the district have experienced different ways of accessing land and land use for agricultural based strategies. Unlike southern parts of the country, existing land tenure of the northern area has evolved from *rist* system, which is hereditary land use right transferred from ancestral holdings. But, in the study area access to land and right to use land were described and several perspectives became evident. People have migrated from highlands in search of unlimited access to land for crop cultivation and livestock production using free grazing since late 1970's. The existing property right of land in the northwestern areas including the study area originated from open access (no defined rights) regime. The same land ownership had been dominantly experienced until 2003, when the massive government sponsored resettlement program (alternative ways of land redistribution) was started and continued for more than a decade.

This study questions why land in most of the lowlands of northwestern Ethiopia has become pressing social, economic, environmental and political issue where relatively the resource abundantly exists. Qualitative data from household surveys and observations indicate that traditionally defined land holding of the farming community for longer period of time before formal land tenure system were evoked, was important strategy of continuing to access land based on long term historical ownership. Higher population pressure, exacerbated by the resettlement program and the livelihood strategies of

farming community- mixed farming of crop and animal production are some of the reasons behind the complex and increasing problems of land use/access and access to surrounding natural resources. Since 2003, the government has changed local farm households' access to land, a practice of claiming certain plot/s with access confirmed by the traditional community leaders to legalize formally via government land registration and certification processes. Despite the fact that the regional government had attempted to complete the second level land certification (SLLC) as part of the first Growth and Transformation Plan (2010/2011 to 2014/2015), land in this study area has not been yet completed, only the first level land certification (FLLC) processes has been undertaken. The failure is partly due to limited implementation capacity of local government and the complexity of the process. As noted by Gizachew et al. (2015), compared to other regions with similar plan, Amhara Regional State has not achieved significant land reform or legalized the use of rural land. Consequently, the smallholders of study area have become the victims of this insufficient rural land registration and certification process with increasing natural resource problems and land related socio-economic disputes among community members. Similar with the findings by Vhughen and Aman (2013), smallholders who are not beneficiaries of the land certification, are suffering from tenure insecurity, which has direct implication on sustainable land use system.

From randomly taken sample households, the plot size per household is found to be 10.03 ha, which is by far greater than the Amhara National Regional State. The interesting finding regarding the ownership of land is the variation between households, between 1 ha minimum to 45 ha per household maximum. The modal land size of households in the study area is 10 ha per household, which is also the maximum plot size per household allowed by government for lowland (*kolla* agro ecology) and is owned by 28.9% of sampled households.

The plot/s that farm households in the study areas owned in term of meeting the needs of households significantly vary from one another. Though, the size of cultivable land per household is more than the national average, 73.3% of households reported that the annual product output is only just meeting household consumption with a few households, 18% able to produced surplus for sale.

### Conservation practices

Sustainable agricultural production is determined by proper utilization and management of land with more emphasis on soil and water conservation. The practice of crop production in this area is shifting cultivation by rotating among different plots of cultivable land after one is fallowed or become at good productivity level. The

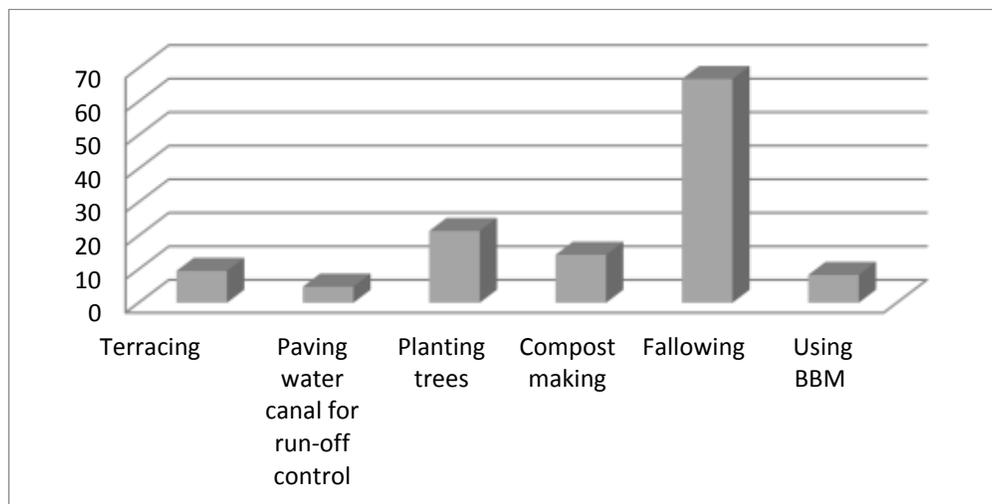
study has revealed that 59% of farm households use shifting cultivation as chief strategy of crop cultivation which includes mainly sorghum, sesame and rarely cotton and legumes. Moreover, analysis also revealed that the practice of shifting cultivation is decreasing from time to time and no longer serves as the key land use and natural resources management strategy due to decreasing trends in plot size per households, which resulted from population increase and strategic land redistribution made by the government. Additionally, it could be also explained that a decrease in natural forest coupled with shrinking of cultivable land compromised the capacity of shifting cultivation, as the farming practice requires forest and fallowing time to recover soil fertility.

The productivity and sufficiency in meeting demands of farm households are important factors, which have direct implication for land use and natural resources conservation including soil and water. Regarding productivity, farm households in the study area have experienced the downward spiral trend. As it has been reported by 91% of households, the productivity of farm land is decreasing for all type of crops cultivated (sorghum, sesame, cotton and legumes). Whether the farming communities in the study area are practicing the soil and water conservation was one of the questions that the study addressed. The data obtained from observation of different plots and focus group discussions with representative of the study population indicated that soil and water conservation practices to enhance or maintain productivity is mainly dominated by fallowing. Fallowing as one of soil productivity enhancement mechanism is practiced by 66.7% of farm households. However, as it has been pointed in the above discussion, fallowing plots as one of productivity enhancement soil conservation technique is not used as it was before because of households are reducing the number of plots to a single plot in many cases and the size of land per households is also becoming less and less as the demand from newly established households increase from time to time.

Terracing, paving water canal for run off control, planting trees and using broad bed maker (BBM), as soil and water conservation strategies and fertilizer application as per recommended rates for soil productivity enhancement are not practiced in the study area and if any, it is not significant and limited to few households. Regardless of the huge potential of the area to easily produce and utilize organic fertilizer, the proportion of households applying to their farm to enhance productivity of soil and get higher output per a given plot is experienced by only 15.1% of households in most cases it experienced using cow dung (Figure 1).

### Livelihoods strategies: Implication on land use

In the areas, where land resource still exists, the livelihood strategies of people determine land use pattern



**Figure 1.** Soil and water conservation practices (n=146).  
Source: household survey data (2015).

and management. Evidence from different sources including local government official documents indicated that 262,104 ha of the land in the study area is convenient for cultivation of different crops, of which nearly 35% has been used for cultivation of different locally growing crops. Following the larger livestock population of the area, about 11% of the total area has been used for open grazing.

Agricultural based livelihood strategies (Scoones, 2009; Frankenberger et al., 2002; Ellis, 1999; Gillespie et al., 1994) which include agricultural extensification, intensification, diversification, and migration have direct land use implication. In connection with it, (Girma and Hassen, 2011) noted that land use and cover change is determined by different combinations of a number of proximate causes and underlying driving forces in varying geographical and historical contexts. The decision of the farming households based on priority of production and available alternatives have also potential impacts on land use strategy. In a broader sense, the livelihood activities can be categorized in two:-farming and non-farming activities (Ellis, 1999).

In agricultural based livelihoods, crop and livestock production are the most important components. In the study area, mixed farming involving crop production as the major and livestock production as minor activity are the chief livelihood activities, which comprises more than 78.1% of sampled households. Other farmers involved in mixed farming livelihood with primary production of animal domestication as primary and crop cultivation as a secondary agricultural based livelihood activity was practiced by 8.2% of sampled households. Sole crop cultivation and animal domestication activities are exercised by 5.5 and 2.7% of farm households respectively.

Agricultural extensification- bringing more land into production using different locally grown crops was found to be the dominant livelihoods strategy of the area studied. Bringing more land into production coupled with the shifting cultivation system is changing the land use of smallholders'. The areas including unproductive, hilly sides and marginal land are being utilized to increase production. Consequently, the land is becoming exposed to deforestation and soil degradations, which compromise sustainable agricultural development (Figure 2).

Agricultural intensification is becoming the emerging population induced livelihood strategies of smallholders in the area as land size per household is shrinking over time. By intensification attempts are made to have more products in limited plot size by increasing input technology and labor intensification. However, as it was noted by Adugnaw (2014) that low agricultural technologies and lack of awareness are causing the natural resources degradation in Ethiopian highlands, the areas studied has experienced poor soil and water conservation, limited fertilizer utilization culture of smallholders, weak agricultural extension system and erratic rainfall which are all contributing to decrease in soil fertility and productivity.

Agricultural diversifications, in which farm households use different agricultural based livelihood portfolios, are important strategies. The livelihood activities in northwestern of country under this broader agricultural based strategy are crop and animal production complementing each other. Nonetheless, increasing in shortage of land has compromised diversified crop cultivation of farming community as different crops require independent land and proper agronomic management practices. Livestock domestication is important and still dominated by a traditional way of



**Figure 2.** The top of mountain area being cultivated, June, 2015.

farming. From randomly taken households, the average cattle ownership is found to be 14.96 Tropical Livestock Unit (TLU) excluding small ruminant, swine and poultry per household. The free grazing system to feed the larger livestock population in the area is also the threat affecting sustainable land use and causing natural resource degradation as observed in the form of deforestation, land fragmentation, soil erosion and loss of fertility. Due to weak livestock extension system strategies to integrate crop-livestock components of farming systems has had little attention or support in the best ways to manage the crop-livestock interactions. The interesting thing with all livelihoods strategies on the productivity of land is found to be decreasing from year to year. 93.2% of sampled households have reported that the productivity of land is decreasing from time to time and is very significant in sole cropping system of cultivation in which up to 30% production drops per cropping season in a given plot is common.

## Conclusion

Land ownership and the pattern of use over times have experienced different modalities under different geographical, historical and political context. The way of accessing land and livelihood strategies and activities pursued by smallholders under rain fed agriculture have land use implications. Unlike the central highlands and the northern regions of Ethiopia in which land ownerships have originated from ancestral holdings, the northwestern lowlands are explained by traditional open access property rights to land and it is the base for currently existing land use and ownerships. The traditional open access origin of property regimes of land has challenged currently working land use and administration and

resulted in a huge disparity in holding among households. This is the reason that land certification process in the case of studied areas is not yet completed. Consequently, the land and related problems and disputes have escalated over time.

The long-standing traditional agricultural based livelihood strategies of smallholders with poor soil and water conservation practices would not be viable means of living. The complexities arising from transition from traditional to modernized property rights to land and increasing land shortage has diverted smallholders livelihood strategies from agricultural extensification and diversification to population induced agricultural intensification. However, that agricultural intensification in the absence of appropriate agricultural technologies such as improved seeds, recommended fertilizer application, under poor practices of soil and water conservation and traditional management practices as observed in the study areas, results in deforestation, decrease in productivity of land and production losses. This could lead to conclude that unless proper land administration and use is in place based on context specific planning and implementation, the current agricultural based livelihood strategies of the area could not ensure sustainable land use.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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*Full Length Research Paper*

# **The effects of crop market participation in improving food security among smallholder crop producer farmers: The case of Central Ethiopia, Ada'a Woreda**

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Merely providing support on improved yields for increased crop productivity to smallholder farmers can not improve the household food security. But parallel support for market linkages to crop producer smallholders can reap the full benefit of this increased crop productivity because lack of reliable and accessible market linking system has been found to be one of the main constraints faced by smallholder crop producer farmers for their food security improvements. So understanding the effects of crop market participation for the improvements of household food security has essential effects. The focus of this study is analyzing the effects of crop market participation in improving food security among smallholder crop producer farmers in the case of Ada'a woreda, Central Ethiopia. 160 sample size respondents of crop producer smallholder farmers represent this study. Both qualitative and quantitative data were collected from primary and secondary sources. Interview schedules, focused group discussions and key informant interviews were the major data collection methods. Descriptive statistics, Tobit and multinomial logit econometric regression models were employed and operated for the analysis. The result showed that, high, low and medium degree of crop market challenges and arable land size were significantly identified factors and affected household crop market participation intensity negatively. While none degree of crop market challenges and extension service for the household per year were significantly identified factors and affected household crop market participation intensity positively. Multinomial logit regression result revealed that, household crop market participation intensity was found significant at 1% sig. level on both moderately food secured (51\_79) and food secured (80\_102) household food security levels relative to food insecure (0\_50) and showed its positive effect for the household food security improvement. As a result, though household crop market participation intensity influenced the household food security significantly at 1% sig. level but the food insecure situation is the most frequently occurring situation in the woreda. This implies the household crop market participation intensity in the woreda is low and producing crop for the purpose of household consumption rather than for market. Which indicated that crop market challenge reduced ways of interventions by triggering the augmentation of reliable and accessible marketing system through adaptable crop market linking approach is required for the central Ethiopia household food security enhancement.

**Key words:** Crop market participation, food security, smallholders, Central Ethiopia/Ada'a woreda.

## **INTRODUCTION**

Globally, the smallholder farmers are estimated to be around 500 million and produce food to about 80% of the

population, but at the household levels, they themselves continue to be food insecure (Upali et al., 2014). The authors also stated that, those smallholder farmers are paradoxically the poorest and most food-insecure.

Many literature such as "Agriculture for impact" had revealed the necessity of market linking systems for the entire life change of smallholder farmers by taking farm Africa's endeavor as an example claimed that, over the last 25 years, farm Africa has provided essential field level support for improved yields on smallholder farms in Africa. However, it is very clear that without parallel support for market linkages and value addition, smallholders will not reap the full benefit of this increased productivity (Agriculture for Impact, 2013). Thus, defining and researching the capable, possible and acceptable ways to foster reliable and accessible marketing system for the smallholder farmer's food security improvement need high attention.

Government of Alberta (2015) claimed that, marketing should be more than just selling. Marketing includes setting financial goals, assessing risk, exploring pricing and deliver alternatives, seeking market opportunities, and keeping one's pride in check. Moreover, good marketing takes planning, selling discipline, access to good market information and a good understanding of pricing and delivery alternatives. Expecting to price everything at the market peak is unrealistic (Alberta, 2015).

Lack of reliable markets has also been found to be one of the main constraints faced by smallholder farmers. The majorities of smallholder farmers are not capacitated with financial and marketing skills and are unable to meet the quality standards set by fresh produce markets and food processors (Department of Agriculture, Forestry and Fisheries, 2012).

Leykun and Jemma (2014) stated about Ethiopia's agriculture that, the agricultural sector is predominantly subsistence where the major part of farm production is used for household consumption rather than for market. According to these authors, smallholder peasant farms cultivate close to 95% of the total cropped land and produce more than 90% of the total agricultural output. From these we can understand that, lack of reliable markets has also been found to be one of the main constraints faced by the majority of Ethiopian smallholder farmers in the country. Such limitation of reliable and accessible market opportunities, forced those majority smallholder farmers to be less market participant in the agriculture sector specifically in crop market participation that has led its production to be limited merely for household consumption rather than for market. The remaining produced crop from the household

consumption is sold for traders with low prices. Such low crop market participation by smallholders leaves them with little income for long last till the upcoming harvesting season which also exposes them for unimproved food security and to lead vicious life cycle style. Such situation needs intervention as stated by the following literature.

Barrett (2007) claimed that, stimulating increased participation by most smallholders and thus greater reach for price and trade policies in affecting food supplies and farming households' welfare will likely require interventions to address the entry barriers that impede food grains market participation. Smallholders face two basic classes of entry barriers. The first are micro-scale associated with households' insufficient private access to productive assets, financing and improved production technologies with which to generate adequate marketable surplus to make market participation feasible and worthwhile (Barrett, 2007). Therefore, in order to shape the current crop production which is limited merely for household consumption rather than for market, market linking systems for Ethiopian smallholder crop producers is necessarily required to enhance the crop producers sale of output which is highly helpful to improve their household food security; therefore, endeavoring for the establishment of reliable and accessible market opportunities to the Ethiopian smallholder crop producers become necessary not only for household food security improvement but also for further crop producers entire life improvement.

Studies by Williamson (2007), North (1991) and Matungul et al. (2002) claim that, the establishment of new institutions with the intent of lowered transactional cost centered institutional economics are required to reduce the implicit cost (that is, cost of banking and marketing, cost of new partner searching, cost of gathering market information, cost of traveling and waiting time) and to reduce the explicit cost (that is, cost of transport, for example bus fares). In addition, IFDC (2015) claimed that, a certain level of organization among smallholder farmers can be quite beneficial to helping them access markets; improved knowledge of how to access markets and how to engage in transactions in competitive markets is also required. Improved access to timely information on prices is needed so that farmers can respond to market incentives and thereby help improve food security at the family and national levels. Enabling favorable policies that allow for the development of farmer-to-market linkages are required (IFDC, 2015).

Maxwell and Smith claimed that, in the 1970s, "food security" was mostly concerned with national and global food supplies and in the 1980s, the focus of "food security" shifted to questions of access to food at

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household and individual levels (Maxwell and Smith, 1991).

Hoddinott and Yohannes (2002) claimed that, household food security is an important measure of well-being and food security encompasses three dimensions: availability (a measure of food that is, and will be, physically available in the relevant vicinity of a population during a given period); access (a measure of the population's ability to acquire available food during a given period); and utilization (a measure of whether a population will be able to derive sufficient nutrition during a given period). Moreover, the authors stated that, although it may not encapsulate all dimensions of poverty, the inability of households to obtain access to enough food for a productive healthy life is an important component of their poverty (Hoddinott and Yohannes, 2002).

Hoddinott (1999) also claimed that, food security is a concept that has evolved considerably over time and there is much literature on potential household food security indicators. There are approximately 200 definitions and 450 indicators of food security. In addition, in the same work of Hoddinott, dietary diversity, individual intakes, household caloric acquisition and indices of household are identified as the four ways of measuring household food security outcomes. Thus, this study had measured the smallholder crop producer's household food security improvements, due to their market participation in terms of dietary diversity. Based on the Hoddinott description, dietary diversity is the sum of the number of different foods consumed by an individual over a specified time period. Further, this author reported on dietary diversity, as it may be a simple arithmetic sum, the sum of the number of different food groups consumed, sums of the number of different foods within a food group, or a weighted sum-where additional weight is given to the frequency by which different foods are consumed (Weighted Sum is = number of food items + consumption frequency of households individual).

Rios et al. (2009) argues that, market participation is directly associated with the generation of a market surplus, thus production technologies and productive assets affect a household's market participation by influencing its productivity. The author furthering that, on the other hand, local market conditions influence incentives to increase productivity. Moreover, the author stated that, poor infrastructure and weak institutions raise transaction costs that considerably alter production and market participation decisions. As a result, increasing rates of market participation or productivity could have bidirectional synergies, and increasing both could boost living standards. Many studies address the impact of either market participation or productivity on farmers' income, and some studies relate them to each other. Little research to date, however, asks to what extent these factors influence each other and almost no

research examines empirical evidence on this matter at the whole-farm level across a range of countries (Rios et al., 2009).

This study argues that increasing the rate of household crop market participation demands a greater attention for the increment of Ethiopian smallholder crop producers' market participation intensity. This is further supported by the work of Berhanu and Moti (2010) who stated that, the average crop output and crop input market participation of Ethiopian smallholders are 25 and 20%, respectively, which indicate infant market participation situation. The research conducted on this study area showed the degree of smallholder farmers crop market participation for the typical household head is computed to be 22.4% (Leykun and Jemma, 2014). This clearly indicates the degree of crop market participation in Ada'a woreda is smaller than the average output market participation of the country at 25% as aforementioned. The authors also defined that, the degree of crop market participation is the ratio of the gross value of all crop sales to the gross value of all crop production times hundred (Leykun and Jemma, 2014). Thus, the situation of lowered crop market participation intensity in Ada'a woreda related with the average output market participation intensity of the country, triggered the researcher to assess crop market situation of crop producer farmers in the woreda, to identify factors of crop market participation intensity on crop groups of roots/tubers, cereals and beans/groundnuts and the researcher also triggered to analyze the effects of household crop market participation intensity on the improvement of household food security. The researcher believed that the situation needs high attention to establish reliable and accessible marketing system. Because this reliable and accessible marketing system enables crop producer smallholder farmers to have enhanced market participation intensity at the household level and has a capacity to generate increased sale value thereby from that sale value the smallholder farmer households can get income which can be able to improve their household food security. This is further elaborated by the following literatures.

Food security revolves around income generation as much as it does in assuring that aggregate production meets aggregate demand (Alderman, 1992). The author also, empirically stated that, low income appears to be the main constraint to calorie consumption. This is indicated by the pronounced increase of calories with increased income at lower levels of long-run income in the household. Kirimi et al. (2013) claimed that, market participation can play a significant role in reducing food poverty, thus ensuring food security. This suggests that facilitating the expansion of market participation by smallholder farmers can be critical in helping households transition out of food poverty (Kirimi et al., 2013).

Previous studies, such as Leykun and Jemma (2014), Osmani and Hossain (2015), Nwigwe et al. (2009),

Achandi and Mujawamariya (2016), and Berhanu and Moti (2010), focused merely on degree of smallholder market participation and/or determinant factors for smallholder market participation intensity. But uniquely, this study is not limited on the factor identification of household crop market participation intensity on crop groups and on the assessment of crop market situation of crop producer farmers in Ada'a Woreda. The study had further analyzed crop producer smallholder's crop market participation intensity on crop groups of roots/tubers, cereals and beans/groundnuts and its effects for the improvement of household food security which has not been carried out in the country before. In this way, the study bridges the knowledge gap of the effects of household crop market participation intensity for the crop producer household food security improvement by identifying household crop market participation factors and by assessing crop market situations, particularly for the specific area of Ada'a Woreda. This analysis was done by the employment of simple summary of descriptive statistics, tobit and multinomial logit econometric regression models. All were employed to assess crop market situation of crop producer smallholder farmer households in the study area. These were to identify factors of crop market participation intensity on crop groups and lastly the study analyzed the effects of crop market participation intensity for the improvement of household food security.

**MATERIALS AND METHODS**

**Study area**

The study was conducted in Ada'a Woreda of the Eastern Shewa zone located at about 45 km south-east of the capital Addis Ababa. White teff, black teff, wheat, maize, barley, onion, potato, lentils, white/black chickpeas, soy, beans, etc., are the main crops cultivated in Woreda. According to Population Projection from 2014 to 2017 of Central Statistical Agency (CSA, 2013), total rural population of Ada'a Woreda is 155,035, from this 80,537 are male and 62,452 are female.

According to Nigatu et al. (2012), Ada'a Woreda lies between longitudes 38°51' to 39°04' East and latitudes 8°46' to 8°59' North covering a land area of 1750 km<sup>2</sup> on east of Addis Ababa. Most of the land (90%) is plain highland ranging between 1600 and 2000 m above sea level. The Woreda is characterized by sub-tropical climate and receives 860 mm rainfall/annum. In general, the main rainy season occurs between mid-June and September, followed by a dry season that might be intercepted by the short rainy season in February and March (Figure 1).

$$(\text{Crop market participant Pop. of kebele } (k) \times 160 / \text{total pop. of the 4 kebeles}).$$

Numbers of crop market participants of a household were identified, by the degree of market participation which is the ratio of the gross value of all crop sales to the gross value of all crop production times hundred (Table 1).

**Data collection tools and instruments**

Semi-structured questionnaire that had been adjusted with schedule

**Research design and approach**

A cross sectional research design was employed and operated due to its complement to obtain information and to understand the awareness of household market participation to the improvement of household food security and its challenges at one time occasion. Quantitative and qualitative approaches were also employed as both the approaches could provide broader and deeper understanding of the issue

**Population, sample size determination and sampling technique**

Ada'a Woreda is selected as a target population of this study. The sample size for this study was calculated based on the following assumption. The total population of the Ada'a Woreda is about 155,035 as the aforementioned literature in the description part and as carried out by Leykun and Jemma (2014), the degree of market participation of the Woreda is 22.4% which indicated that around 34,728 crop market participants are available; this number is less than 50,000. Therefore, Godden (2004) is appropriate to calculate the sample size. So, the new sample size for the population less than 50,000 is calculated as follows:

$$\text{New SS} = \frac{SS}{(1 + (\frac{SS-1}{Pop}))}$$

where New SS = New Sample size and Pop = Population which is 22.4% (that is, 34,728).

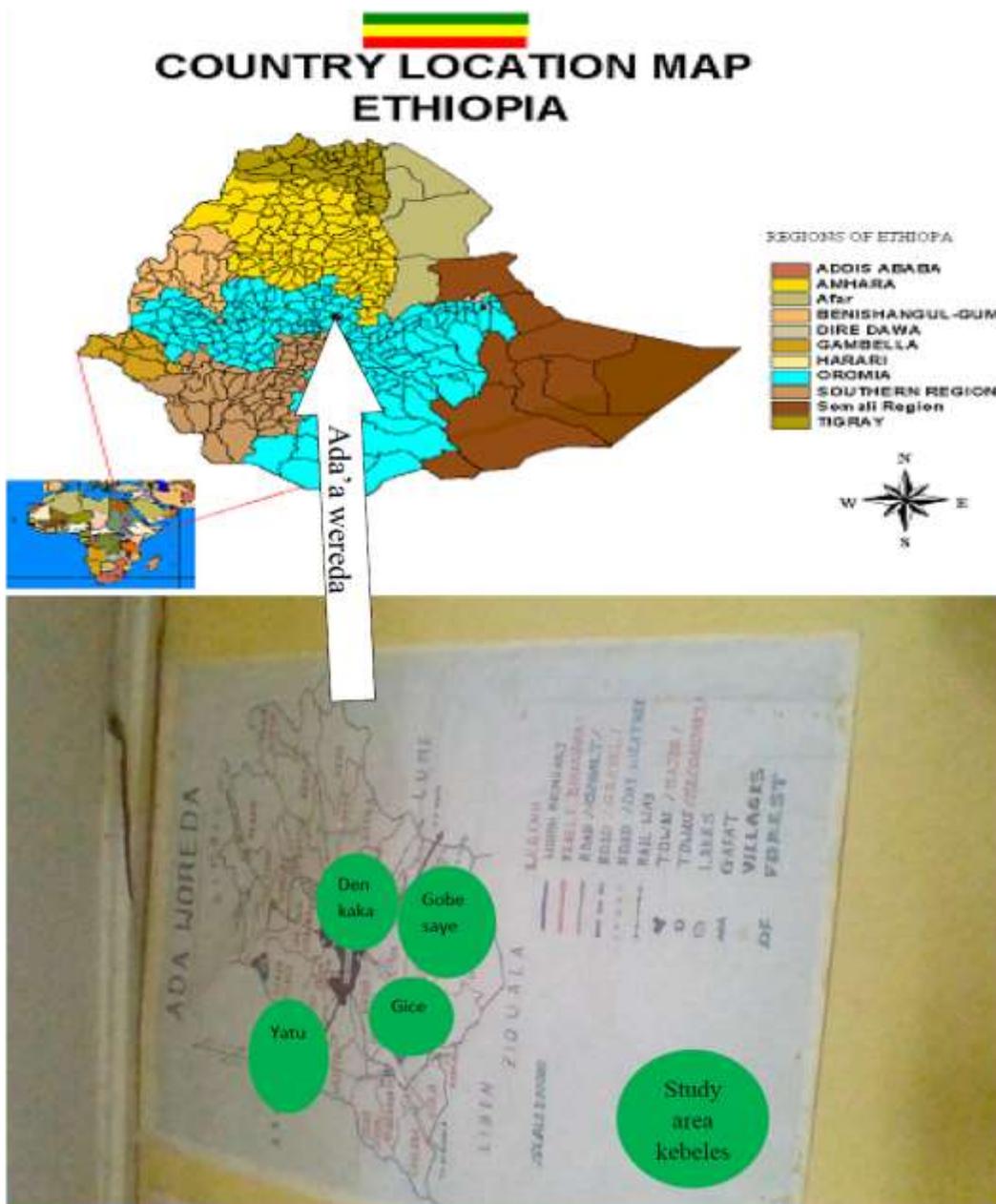
Therefore, assuming that the sample size is 150,

$$\text{New SS} = \frac{150}{(1 + (\frac{150-1}{34,728}))} = 149$$

The total sample of the respondents becomes 149. By assuming 8% for contingency, it becomes 160, according to Ada'a Woreda's finance office data, this sample size can be a representative for total rural household male number 16,793, for total rural household female number 2,776 and for total male number of families under household 42,072 and for total female number of families under household 53,012 household situations in the rural.

The sampling technique for this study was a multi-stage sampling. This was done first by selecting high, medium and low household crop market participants 4 rural kebeles among the 26 kebeles, after stratifying 26 rural kebeles of the study area into 3 stratum (kebeles holding high, medium and low crop market participant households) in the Woreda; by randomizing households within the kebeles. Second, to conduct quantitative survey, respondents from each kebele are determined with a proportional to sample size and simple random sampling is run to each member kebeles of the sampling households in order to have equal chance of being picked for the sample (Table 1):

and translated Amharic and Afan Oromo language translator enumerators for effective communication with 160 respondents were used as the main instrument to quantitative data in order to investigate the association between the dependent and independent variables of the data about the assessment of crop market situation of crop producer farmers in Ada'a Woreda, factors affecting crop market participation and effects of smallholder crop market participation on food security at the household level of the



**Figure 1.** Map of the study area Ada'a Woreda from the country location map of Ethiopia.  
 Source: Rearranged from goggle earth ([www.google earth](http://www.google-earth.com)) and taken from Ada'a Woreda finance office.

**Table 1.** Proportional sample size determination.

Selected Kebeles	Total No. of hhs under expected market participants	Formula	Proportional sample size
Yatu	2,036	$2,036 \times 160 / 18,490$	17
Denkaka	7,607	$7,607 \times 160 / 18,490$	66
Gice	2,860	$2,860 \times 160 / 18,490$	25
Gobesaye	5,987	$5,987 \times 160 / 18,490$	52
Total	18490	-	160

Source: Own construct (2017).

smallholder farmers.

A key informant interview of an open-ended questionnaire interview guide was the other tool which had been applied for purposively selected expert of agriculture extension service deliverers in Ada'a Woreda that was held face to face and for qualitative information that was about the assessment of crop market situation of crop producer farmers in Ada'a Woreda, factors affecting smallholder crop market participation intensity and effects of crop marketing on food security.

Focus group discussion is the other enhancing tool which was conducted by purposively selected participants in the intent of 160 sample size household representation that was applied for household heads who were highly facing crop market challenges, none facing ones and moderately facing ones of the challenges were those from formally organized structured groups of individuals from crop marketing associations and individuals from Equb and Edir (Ethiopian Cultural Social Associations self-formation to help each other), among which both active crop market and less crop market participants were selected and also from other concerned households who came together and discuss on a series of issues within limited time period. Thus qualitative information was about the assessment of crop market situation of crop producer farmers in Ada'a Woreda; factors affecting smallholder crop market participation intensity and effects of crop marketing on food security were discussed.

**Methods of data analysis**

**Descriptive statistics**

For specific objective, to assess crop market situation of crop producer farmers in Ada'a Woreda, the study used descriptive statistics in order to describe variables which was done by employing simple statistical summary by operating the variables mean, standard deviation, minimum and maximum values.

**Regression analysis and rationales of using Tobit and multinomial logit models**

To address specific objective (2), that is, to identify factors affecting crop market participation intensity for smallholder crop producer farmers' in Ada'a Woreda, the study used Tobit econometric regression model. James Tobin who proposed Tobit model for the first time in 1958 had explained the necessity of Tobit model by stating that, in economic surveys of household, many variables have a lower or upper limit and takes on the limit value for a substantial number of respondents. For the remaining respondents,

$$Y^* = \beta_0 + P_1X_1 + P_2P_2 + P_3X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 \dots P_kX_k + \varepsilon_i$$

$$mp = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 \dots \beta_i + X_i + \varepsilon_i$$

$$mp = \alpha + \beta_1Sex + \beta_2Age + \beta_3Edu + \beta_4Groupmark + \beta_5Dis + \beta_6Markinfo + \beta_7Transportcost + \beta_8ACC + \beta_9D - Ratio + \beta_{10}price + \beta_{11}exten + \beta_{12}Markpartipn + \beta_{13}salevalue + \beta_{14}Electric + \beta_{15}Land + \beta_{16}dcmc + \beta_{17}mcfcm + \beta_{18}pgc + \beta_{19}ahh + \varepsilon$$

where  $\alpha$  = is an intercept,  $\beta_i$  = a parameter to be estimated,  $X$ = is a vector of explanatory variable, and  $\varepsilon$  = is the error term.

To address the specific objective (3), multinomial logit econometric regression model, which was adopted and modified from Richard (2017), has been employed. As explained earlier, this specific objective is to analyze the effects of crop market

the variable takes on a wide range of values above or below, the limit (Tobin, 1958). Thus, for doing such variable characteristics survey of households, this Tobit model is essential. Nevertheless, here James Tobin agrees that, the sample may give unbiased estimates of the parameters of the relationship, even though it gives biased estimates of the separate frequency distribution of the variables. For such sample selection biased estimation problems (Gujarati, 2003) suggested as Heckman model is appropriate. Moreover, Fernando (2011) claimed the reasoning behind using Tobit model by stating that, if we include the censored observations as  $y = 0$ , the censored observations on the left will pull down the end of the line, resulting in underestimates of the intercept and overestimates of the slope. If we exclude the censored observations and just use the observations for which  $y>0$  (that is, truncating the sample), it will overestimate the intercept and underestimate the slope. The degree of bias in both will increase as the number of observations that take on the value of zero increases. The Tobit model uses all the information, including information on censoring and provides consistent estimates (Fernando, 2011).

To achieve specific objective (3), that is, to analyze the effect of crop market participation on household food security, the study used multinomial logit econometric regression model. As stated by Richard (2017), when categories are unordered, multinomial logistic regression is one often-used logistic strategy. Mlogit models are a straightforward extension of logistic models.

**Specification of the models**

For achieving specific objective (2), that is, to identify factors affecting crop market participation intensity for smallholder crop producer farmers' in Ada'a Woreda, following Gujarati (2003), the study employed the Tobit model on the sampling procedure that was followed during survey data collection. Based on the aforementioned literature by Fernando (2011) explanation since Tobit model uses all of the information, including information censoring from below and above threshold points and provides consistent estimates, it has been chosen and applied.

For this specific objective (2), following Gujarati, the Tobit model is specified as follows:

$$Y_i^* = \alpha + \beta X_i + \varepsilon_i \quad i = 1, 2 \dots n$$

$$Y_i = Y^* \text{ if } Y^* > 0$$

$$Y_i = 0 \text{ if } Y^* \leq 0$$

where  $Y^*$  is a censored variable of the household (h) market participation (mp):

participation on household food security improvement. According to the author, the study supposed that household food security has M or three categories. Among these categories, one value (typically the first, the last, or the value with the highest frequency) of among the household food security level is designated as the reference category. For household food security with M (three) categories,

this requires the calculation of M-1 equations, one for each category relative to the reference category, to describe the relationship between the household food security levels and the reference groups.

Hence, if the first category is the reference, then for  $m = 2 \dots M$ ,

$$\ln \frac{P(Y_i = m)}{P(Y_i = 1)} = \alpha_m + f(x) = \alpha_0 + \sum_{k=1}^K \beta_{mk} X_{ik} = Z_{mi}$$

For each case, there will be M-1 predicted log odds, one for each category relative to the reference category (Note that when  $m = 1$ , we get  $\ln(1) = 0 = Z_{11}$  and  $\exp(0) = 1$ ).

When there are more than 2 groups, computing probabilities is a little more complicated than it is in logistic regression. For  $m = 2 \dots M$ ,

$$P(Y_i = m) = \frac{\exp(Z_{mi})}{1 + \sum_{h=2}^M \exp(Z_{hi})}$$

For the reference category,

$$P(Y_i = 1) = \frac{1}{1 + \sum_{h=2}^M \exp(Z_{hi})}$$

In other words, the study takes each of the M-1 log odds, thereby computed and exponentiate it. Once the calculation of the probabilities is straightforward, note that, when  $M = 2$ , the mlogit and logistic regression models (and for that matter the ordered logit model) become one and the same. Where,

$\alpha$  is an intercept and  $Y_i$  = Continuous unmeasured variable (latent

Variable) in this case household food security improvement on crop groups (i),  $X_{ki}$  = is the effects influencing household food security improvement on crop groups (i),  $\beta$  and M-1= are parameters to be estimated.

As the aforementioned literature of Leykun and Jemma (2014), defined the degree of market participation, which is as the ratio of the gross value of all crop sales to the gross value of all crop production times hundred. Therefore, this can be the measurement for the level of crop market participation intensity on crop groups to this study. Matungul et al. (2002) also empirically indicated that, food crop income of the household is explained by the sale value of the crop producer, sale value represents the total food crop income in birr of marketed output per household that affect the household food security directly. So the household sale value raises the household crop market. Participation intensity increases, this in turn increases the household income and thus enhances the household food security.

From the aforementioned formulas, household crop market participation intensity on crop groups and other transactional cost related explanatory variables had shown their effect on dependent variable household food security for the third objective via multinomial econometric regression model. The value of household food security outcomes of smallholder crop producer farmers was at measured by dietary diversity as the aforementioned literature the introduction part. Whereas the value of household crop market participation intensity on crop groups was measured with the ratio of the gross value of all crop sales to the gross value of all crop production times hundred.

The hypothesized explanatory variables have been signified in Table 2 for the Tobit regression models and multinomial logit model

so as to operate objective two and objective three, respectively; the estimation for those hypothesized explanatory variables was mainly based on Matungul et al. (2002).

Based on empirical indication of Matungul et al. (2002) the model hypothesizes that food crop revenue is explained by marketing participation intensity; as crop producer's market participation increases, their income increases and as their income increases the tendency to secure their household food security increases. But for doing so smoothly, there are estimated signs shown in the hypothesized explanatory variables in Table 2, which show the negative and positive aspect factors of estimated variables for the household crop market participation intensity of smallholder crop producer farmers and the negative and positive aspect effect for their household food security improvements.

As mentioned earlier, the main objective of this study is to analyze the effects of crop market participation among smallholder crop producer farmers in improving their food security at the household level. The study is mainly based on primary data that has been collected from 160 respondents of Ada'a Woreda. The required data was collected by following a standard sampling technique from the crop producer smallholder farmers in the study area. Random sampling technique for the household respondents has been applied to select the sampled households. So the study has analyzed and discussed by applying the aforementioned Tobit and multinomial logit econometric models for objectives two and three, respectively and descriptive statistics of simple quantitative summary of data set has been employed and operated for the description purpose of specific objective one.

## Diagnostic test

Richard defined heteroskedasticity by considering Wikipedia's meaning which stated that, if the error terms do not have constant variance, they are said to be heteroskedastic [Tidbit from Wikipedia: The term means "differing variance" and comes from the Greek "hetero" ('different') and "skedasis" ('dispersion') (Richard, 2015)]. To check whether the error terms have constant variance, hettest (hetroskedacity test) is employed.

Before the start of complete analysis, an assortment of diagnostic tests was conducted to make the data ready for regression and also after regression, model fitness was checked. So, VIF (variance inflation factor test), pwcorr (pair wise correlation), hettest (hetroskedacity test) have been implemented before running Tobit econometric regression model for the second objective. pwcorr (pair wise correlation) and ovtest (omitted variable test) have been applied for the multinomial logit model for the third objective. After running Tobit regressions for the second objective, linktest (link test for model specification) and margins (marginal means, predictive margins, marginal effects, and average marginal effects) tests were seen. While after running multinomial logit regression, margins (marginal means, predictive margins, marginal effects, and average marginal effects) tests have been seen. Further for Tobit econometric model, Prob > Chi<sup>2</sup>=0.000 has been considered to check the model goodness of fit (Table 5). Moreover, for multinomial logit econometric model, the likelihood ratio Chi<sup>2</sup> of 132.34 which can be calculated by  $-2 \times (L(\text{null model}) - L(\text{fitted model})) = -2 \times ((-163.34) - (-97.17)) = 132.34$  with a p-value < 0.0001 tells us that our multinomial model as a whole fits significantly better than any empty model.

## RESULTS AND DISCUSSION

### Descriptive statistics

To assess household crop market situation of crop

**Table 2.** Effects of hypothesized independent variables on dependent variable household food security via multinomial logit model and factors of hypothesized independent variables on dependent variable household market participation via Tobit model in Ada'a Woreda, 2017.

Variable	Code	Description	Expected sign	Source
Age	Agehead	Age of the household head (in years)	±	Matungul et al. (2002)
Sex	Sexhead	Gender of the household head (For female=1, for male=2)	±	Estimation
Education	Eduhead	Education level of the household head (literate=1, illiterate=0)	±	Estimation
Distance	Dis	Household distance from the crop market (1if household has Donkey/s,0 otherwise)	-	Estimation
Dependency ratio	D-Ratio	Dependency ratio in the household (consumers/on farm worker, 1 if available, 0 otherwise)	-	Estimation
Extension	Exten	membership of the household to extension service (1 if yes, 0 otherwise)	+	Estimation
Market Information	Mi	Household has access to market information (1 if yes, 0 otherwise)	+	Estimation
Transport cost	Trancost	Cost of household to transport crop to the market (1if they pay, 0 otherwise)	-	Estimation
Electricity	Electric	Household has electric access (1if yes, 0 otherwise)	+	Matungul et al. (2002)
Land size	Land	Amount of arable land for household in hectare/s	+	Matungul et al. (2002)
Group markets	Gm	A household head participates in a group crop markets (1if yes, 0 otherwise)	+	Estimation
Price	Price	Price of crop in the market (1if high, 2 if low, 3 if medium)	+	Estimation
Crop market participation	Mp	Household crop market participation intensity on crop groups (4=Roots/Tubers, 5=Cereals, 6=Beans/Groundnuts)	+	Matungul et al. (2002)
sale value	Salevalue	The amount of sale value of crop for a household in birr (1 if sale 100%, 0 otherwise)	+	Estimation
dcmc	0.dcmc	None degree of crop market challenge	+	Estimation
Dcmc	1.dcmc	high degree of crop market challenge(no market place, no financial institution(s), no/low infrastructure and others)	-	Estimation

Table 2. Contd.

dcmc	2.dcmc	Low degree of crop marketing challenge (no financial institution/s)	-	Estimation
dcmc	3.dcmc	Medium level of crop market challenge(no market place, no financial institution)	-	Estimation
pgc	4.pgc	Roots/Tubers producing groups of crops	+	Estimation
pgc	5.pgc	Cereals producing groups of crops	+	Estimation
pgc	6.pgc	Beans/Groundnuts producing groups of crops	+	Estimation
ahh	Ahh	Activity of household head	+	Estimation
ms	Ms	Marital status of household head	+	Estimation

producer farmers in Ada'a Woreda, to identify factors affecting crop market participation intensity and to analyze the effects of crop market participation on household food security, sample of 160 households were taken from 4 selected rural kebeles of Yatu, Gice, Gobesaye and Denkaka which are found under Ada'a Woreda, Central Ethiopia. Thus, all samples of the households are used for analysis.

#### ***Situation of household crop market participation in Ada'a Woreda, Central Ethiopia***

The household crop market situation in Ada'a Woreda is shown in Table 3; the maximum households' crop market participation intensity is 100 and the minimum is 0, whereas the mean average value of crop market participation intensity is 39.87. For the degree of crop market participation challenges, the high, low and medium degree of crop market challenges mean value was found around 36, 23 and 21%, respectively, only the remaining 20% was none degree of crop market challenges. In Table 2, the degree of crop market challenges categorized under the variable high is: no market place, no financial institution/s, no/low infrastructure, etc.

#### ***Situation of household food security in Ada'a Woreda, Central Ethiopia***

The household food security situation in Ada'a Woreda is shown in Table 4; from the total 160 sampled households, 50% of household food security situation is the most frequently occurring household food insecure/unimproved situation, 31% of those respondents were moderately food secured situation and the remaining

19% of the respondents household were food secured. This result shows that food insecure/unimproved situation is the most frequently occurring household food security situation in Ada'a Woreda and can be the reference group in this description and for the regression outcomes.

#### ***Factors affecting crop market participation intensity***

In the descriptive statistics, factors affecting crop market participation intensity in the woreda has also been described by using simple summary of descriptive statistics method. Moreover, to identify statistical significant factors that have been affecting crop market participation intensity of a household, Tobit econometric regression model has been employed and operated here. The aforementioned literature of Tobin (1958) and Fernando (2011), in general can be stated as the Tobit model is also mostly called a censored regression model; even though the model is nonlinear model and similar to the probit model, it is designed to estimate linear relationships between variables when there is either left- or right-censoring in the dependent variable (also known as censoring from below and above, respectively). Based on these authors claim, censoring from above takes place when cases with a value at or above some threshold, all take on the value of that threshold, so that the true value might be equal to the threshold, but it might also be higher. In the case of censoring from below, values of those that fall at or below some threshold are censored. Therefore, a Tobit model can be used to predict an outcome that is censored from above, from below, or both, Tobit regression will generate a model that will predict the outcome variable to be within the specified range.

In this study, a censored variable is household crop market participation of Ada'a Woreda's smallholder crop

**Table 3.** Household crop market situation in central Ethiopia Ada'a Woreda.

Variable	Obs	Mean	Std. Dev.	Min	Max
mp	160	39.87313	25.60212	0	100
exten	160	0.65625	0.4764501	0	1
mi	160	0.5875	0.4938299	0	1
tcgp	160	25.70625	25.93111	0	153
electric	160	0.5625	0.4976359	0	1
land	160	2.098719	1.408167	0	12.3
asset	160	0.70625	0.4569089	0	1
<b>pgc</b>					
cereals	160	0.21875	0.4146966	0	1
beans/gro~s	160	0.35625	0.4803939	0	1
<b>dcmc</b>					
high	160	0.35625	0.4803939	0	1
low	160	0.23125	0.4229557	0	1
medium	160	0.2125	0.4103611	0	1

Source: Own Survey Data (2017).

**Table 4.** Household food security situation in central Ethiopia Ada'a Woreda.

Household food security situation in Ada'a woreda	Freq.	Percent	Cum.
Food insecure/unimproved (0-50 weighted sum)	81	50.62	50.63
Moderately food secured (51-79 weighted sum)	49	30.63	81.25
Food secured (80-102 weighted sum)	30	18.75	100.00
Total	160	100.00	-

Source: Own Survey Data (2017).

producer farmers. For this purpose, Tobit regression is applied to generate a Tobit model which predicts the household food security outcome to be within the set of specified range of explanatory variables. These set of hypothesized explanatory transaction cost related variables which were included and analyzed in the Tobit model are shown in Table 2. Among those set of hypothesized explanatory transaction cost related variables, household crop market participation intensity on crop groups of roots/tubers, cereals and beans/groundnuts (mp), degree of crop market challenges (dcmc) which were facing crop market participation intensity, extension service for the household head per year (exten), producing groups of crops for a household (pgc), accessibility of electricity (electric) and market information (mi), availability of asset (asset) and arable land (land) and household total amount of total crop group production of household (tcgp), were the specified range of explanatory variables in this Tobit regression model. Moreover, those explanatory transactional costs related variables were taken into the responds of

household interview, key informant interview and focus group discussions to identify factors of household crop market participation intensity.

As shown in Table 5, the Tobit regression estimation result has been identified as there were variables that have explanatory power on crop market participation intensity of smallholder crop producer households in Ada'a Woreda at 1, 5 and 10% level of significance.

Since a Tobit model can be used to predict an outcome that is censored from above, from below, or both, for this study, the household market participation has been listed (outcome variable) followed by the factor predictors of extension service for the household per year (exten), market information (mi), amount of total crop group production of household (tcgp), accessibility of household electricity and asset, arable land of household, crop producing groups of household (pgc) degree of crop market challenges (dcmc) and then, upper limit of the outcome variable which is done to generate a Tobit model in stata has been specified. Lastly, the output is signified as follows in Table 5.

**Table 5.** Tobit econometric regression estimation result identified factors affecting smallholder's household crop market participation intensity.

Variable	(1)	(2)	Margins, at (exten mi tcgp electric land asset pgc dcmc)
	Model [Coff.(SE)]	Sigma [Coff.(SE)]	Expression linear prediction, predict()At
Exten	8.126* (4.179)	-	0.65625 (mean)
Mi	-2.599 (4.300)	-	0.5875 (mean)
Tcgp	0.105 (0.0737)	-	25.70625 (mean)
Electric	1.580 (4.148)	-	0.5625 (mean)
Land	-3.389*** (1.230)	-	2.098719 (mean)
Asset	3.578 (3.913)	-	0.70625 (mean)
5.pgc	7.648 (4.727)	-	0.21875 (mean)
6.pgc	1.718 (4.483)	-	0.35625 (mean)
1.dcmc	-41.70*** (6.077)	-	0.35625 (mean)
2.dcmc	-20.86*** (5.003)	-	0.23125 (mean)
3.dcmc	-13.57** (5.648)	-	0.2125 (mean)
Constant	57.46*** (8.244)	18.37*** (1.066)	-
Observations	160	160	-

Obs. summary: 0 left-censored observations; 152 uncensored observations; 8 right-censored observations at  $mp \geq 83$ ; \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . Tobit regression: Number of obs = 160; LR  $\chi^2(11) = 108.04$ ; Prob >  $\chi^2 = 0.0000$ ; Log likelihood = -667.12623 Pseudo  $R^2 = 0.0749$ .

Source: Own Survey Data (2017).

The log likelihood result of the Tobit model from Table 5 indicated as the model is the fitted model. This is used in the likelihood ratio  $\chi^2$  test of whether all factor predictors' regression coefficients in the model are simultaneously zero. The likelihood ratio (LR) chi-square test that is at least one of the factor predictors' regression coefficients is not equal to zero. The number in the parentheses indicates the degrees of freedom of the  $\chi^2$  distribution used to test the LR  $\chi^2$  statistic and is defined by the number of predictors in the Tobit model. From Table 5, Prob >  $\chi^2$  is the probability of getting a LR test statistic as extreme as, or more so, than the observed statistic under the null hypothesis. The null hypothesis is also explained in the above, that is, all of the regression coefficients are simultaneously equal to zero. In other words, this is the probability of obtaining this  $\chi^2$  statistic (108.04) or one more extreme if there is in fact no effect of the predictor variables. This p-value is compared to a specified alpha level, our willingness to accept a type I error, which is typically set at 0.05, 0.01 or 0.1. The small p-value from the LR test, <0.0001, would lead us to conclude that at least one of the regression coefficients in the model is not equal to zero. The parameter of the  $\chi^2$  distribution used to test the null hypothesis is defined by the degrees of freedom as explained in the prior line. The regression coefficients displayed in Table 5 with the abbreviation "coef." is to mean coefficient. Tobit regression coefficients are interpreted in similar manner to ordinary least squares (OLS) regression coefficients; however, the linear factor is on the uncensored latent variable, not the observed outcome. The expected household food security score changes by coefficient for each unit, if the coefficient is

negative decrease in the corresponding predictor and if the coefficient becomes positive increase in the corresponding predictor. So from Table 5, effect predictor factor coefficients of household arable land, high degree of crop market challenges, low degree of crop market challenges and medium degree of crop market challenges for Ada'a Woreda smallholder household crop market participation intensity have denoted negative coefficient factors which implies the expected household crop market participation intensity score change decreases by coefficient for each unit, on these effect predictor factors. Whereas on effect predictor factor coefficient of none degree of crop market challenge and extension service for the household per year have denoted positive coefficient that implies the expected household crop market participation intensity score change increases by coefficient for each unit, on these effect predictor factors. This is clearly shown in Table 5.

From Table 5, "Obs. summary" means observation summary that indicates how many of the observations in the dataset are censored. Here, we see that zero or none of the observation in the data set is left censored and 8 of the observation in the data set are right censored at household market participation intensity (mp) greater than or equal to 83. Moreover, from Table 5, "Number of obs." means number of observations that is the number of observations in the dataset, all of the response and predictor variables are non-missing, that is, all of the 160 responses and predictor variables were none missed. Therefore, based on the explanation and as shown in Table 5, the effect predictor factors of arable land, high degree of crop market challenge and low degree of crop market challenges were found significant at 1% level and

the other medium degree of crop market challenge effect predictor factor was found significant at 10% level while extension service for the household per year was found significant at 5% level. In addition to these, Table 5 shows the effect predictor factors on the household crop market participation intensity that have been included on the categorical variables but not displayed on the Tobit regression output. These effect predictor factors were roots/tubers producing groups of crops from producing groups of crop categorical variable and none degree of crop market challenge from degree of crop market challenges categorical variable. So these variables are considered as their coefficients and standard error values are the constant value of the Tobit model and since the constant value of the model from Table 5 denoted significant at 1% level, thus the effect predictor factor of root/tuber producing groups of crops and the effect predictor factor of none degree of crop market challenge were also significant at 1% level.

Further, the Tobit regression result revealed as there were effect predictor factors of market information, total amount of crop group production for household, electric accessibility, availability of asset, producing groups of cereal crops and producing groups of bean/groundnut crops were insignificant which showed their insignificance on outcome variable of household crop market participation intensity (Table 5).

In general, from Table 5, it can be generalized that based on the effect predictor factors significance level and based on the case of censoring at the threshold points of the absolute t value on the output of household crop market participation intensity dependent variable, the independent variable high degree of crop market challenge was found to be the highest negatively affecting factor on the household crop market participation intensity at 1% significance level among all included effect predictor factors at the t absolute value 6.86, while arable land, low and medium degree of crop market challenges were found to be the next negatively affecting factors for household crop market participation intensity in Ada'a Woreda smallholder crop producer farmers. Whereas none degree of crop market challenge was found to be the highest positively affecting factor for household crop market participation intensity at 1% significant level. Moreover, extension service was also found to be the positive factor for household crop market participation intensity in Ada'a Woreda's smallholder crop producer farmers (Table 5).

**Degree of crop market challenges (dcmc):** This variable is categorical variable and the Tobit model regression result shows the same as the hypothesized estimation result in Table 2. High and low degree of crop market challenges were significant at 1% significant level and medium level of crop market challenge was significant at 10% significant level, all of these have been included on this degree of crop market challenges (dcmc)

independent categorical variable. Table 2 shows that under high degree of crop market challenges, no market place, no financial institution/s, no or low volume of infrastructure challenge for household crop market participation intensity were the factors and no financial institutions was the factor for low degree of crop market challenges while no crop market place and no financial institutions/s were the factors under medium level of crop market challenges. Among them, high degree of crop market challenge was found to be the highest negatively affecting factor for household crop market participation intensity at 1% significant level and censoring from the above at 6.86 absolute t values in Ada'a Woreda's smallholder crop producer farmers. Therefore, this Tobit model regression estimation result in Table 5, verified the results described on descriptive statistics using simple summary statistics.

**Arable land size:** The size of arable land was hypothesized as it would have positive influence on the crop market participation intensity of smallholder households. As hypothesized, a larger area of arable land helps to reduce transaction costs per unit of output and would positively be related to smallholder crop market participation intensity but in Table 5, the Tobit regression result showed negative sign but statistically significant at 1% level. From the result, we understand that, household crop market participation intensity was negatively affected by the low size of arable land for Ada'a Woreda's crop producer smallholder household farmers which were found not to be larger as hypothesized and negatively affecting factor for the household market participation intensity.

**Extension service for the household per year:** This is an independent variable that denotes the provision of extension services for a household in a year within Ada'a Woreda smallholder crop producer farmers. The Tobit regression result in Table 5 is as similar as the hypothesized estimation result in Table 2. As hypothesized, the regression result is found statistically significant at 5% level for household crop market participation intensity of smallholder crop producer farmers in the woreda and as the hypothesized estimation result, the coefficient of the Tobit regression result indicated positive factor with household crop market participation intensity of smallholder crop producer farmers. But the significance level and when censoring from the above, the absolute t value which is 1.94 indicated at the lowest level. This lowest level Tobit regression result fits with the information found on the key informant interview and focus group discussions collected data. Those collected data showed that almost all of extension service deliverer's main duty is on crop productivity. The qualitative information gathered on both key informant interview and focus group discussions implied that, the extension deliverer's service provision is

mainly based on crop productivity without incorporating market linking issue. The lowest level effect implies the extension service in the Woreda triggered to decrease the likelihood of household crop market participation intensity on producing groups of crops with time. Therefore, it is highly advisable to give attention for the provision of extension services in the intent of triggering crop market participation (sale of output) intensity parallel with crop productivity issues which calls high attention for the focus of delivering extension services on crop market linking issues in Ada'a Woreda. The marginal effect predicted probability after Tobit regression, by setting predictor factors to the specific value is shown in Table 5. As the aforementioned concept, in Tobit regression the outcome (dependent) variable is household crop market participation intensity. In this case, the variable household crop market participation intensity marginal effect after Tobit regression in Table 5 is indicated as factor variables are at their mean value.

### ***The effects of crop market participation on household food security***

In the descriptive statistics, in addition to describing the assessment of crop market situation of crop producer farmers with the association of food security in Ada'a Woreda, the effects of household crop market participation intensity on household food security in the Woreda has been also described by using descriptive statistics method with the application of simple statistical summary of descriptive statistics. Further to analyze statistical significant effects which have been influencing household food security of Ada'a Woreda's smallholder crop producer farmers, multinomial regression model was employed and operated in this section.

Based on the aforementioned literatures, when categories are unordered, multinomial logistic regression is one often-used strategy. Mlogit models are a straightforward extension of logistic models. Moreover, according to Williams (2017), this study supposed that household food security has M or three categories. Among these categories, one value (typically the first, the last, or the value with the highest frequency) of among the household food security level is designated as the reference category. For household food security with M (three) categories, this requires the calculation of M-1 equations, one for each category relative to the reference category, to describe the relationship between the household food security levels and the reference groups.

In this study, a response variable is household food security of Ada'a Woreda's smallholder crop producer farmers. For this purpose, multinomial regression is applied to generate a multinomial model. Multinomial model predicts the household food security outcome within the set of specified range of explanatory variables. These set of hypothesized explanatory transaction cost

related variables which were included and analyzed in the multinomial model are summarized in the results and discussion (Table 2). Among those set of hypothesized explanatory transaction cost related variables, household crop market participation intensity (mp), degree of crop marketing challenges (dcmc), extension service for the household head per year (exten), producing groups of crops (pgc), access of household market information (mi), amount of total crop group production of household (tcgp), access of electric (electric), access of asset (asset) and availability of arable land (land) were the specified range of explanatory variables in this multinomial regression model.

Moreover, those explanatory transactional costs related variables were taken into the responds of household interview, key informant interview and focus group discussions to analyze the effects of household crop market participation on the dependent variable of improvement of household food security.

As shown in Table 6, the multinomial regression estimation result analyzed that there were variables that have explanatory power effects on the household food security improvements of crop producer farmers in Ada'a Woreda at 1, 5 and 10% level of significance.

Table 6 and Appendix E show the multinomial model regression estimation result as the following. The outcome status of the three unordered categories under multinomial logit model are coded as weighted sum 0\_50=Food insecure, weighted sum 51\_79= moderately food secured and weighted sum 80\_102 =Food secured. The predictors are: household market participation intensity (mp), household extension service per year (exten), access of household market information (mi), amount of total crop group production of household (tcgp), access of electric service for household (electric), access of asset for household (asset), type of producing groups of crops (pgc) and degree of crop market challenges (dcmc).

Iteration log is a listing of the log likelihoods at each iteration point. Remember that multinomial logistic regression, like binary and ordered logistic regression, uses maximum likelihood estimation, which is an iterative procedure. The first iteration (called iteration 0) is the log likelihood of the "null" or "empty" model, that is, a model with no predictors. At the next iteration, the predictor(s) are included in the model. At each iteration point, the log likelihood increases because the goal is to maximize the log likelihood. When the difference between successive iterations is very small, the model is said to have "converged", the iterating stops, and the results are shown in Table 6. In the output, we first see the iteration log, indicating how quickly the model converged. The log likelihood (-97.169981) can be used in comparisons of nested models, but this study did not show an example of comparing models here. The likelihood ratio  $\chi^2$  of 132.34 with a p-value < 0.0001 tells us that this model as a whole fits significantly better than an empty model (that

**Table 6.** Multinomial logit regression estimation result analyzed effects of crop market participation on smallholders' household food security.

Variable	(1)		(2)		(3)		Margins at (mp exten mi tcgp electric land asset pgc dcmc) Expression Pr(fs==0_50), predict ()
	0_50	51_79	[Coef.(SE)]	[Coef.(SE)]	80_102	[Coef.(SE)]	
o.mp	-	-	-	-	-	-	39.87313 (mean)
o.exten	-	-	-	-	-	-	0.65625 (mean)
o.mi	-	-	-	-	-	-	0.5875 (mean)
o.tcgp	-	-	-	-	-	-	25.70625 (mean)
o.electric	-	-	-	-	-	-	0.5625 (mean)
o.land	-	-	-	-	-	-	2.098719 (mean)
o.asset	-	-	-	-	-	-	0.70625 (mean)
5o.pgc	-	-	-	-	-	-	0.21875 (mean)
6o.pgc	-	-	-	-	-	-	0.35625 (mean)
1o.dcmc	-	-	-	-	-	-	0.35625 (mean)
2o.dcmc	-	-	-	-	-	-	0.23125 (mean)
3o.dcmc	-	-	-	-	-	-	0.2125 (mean)
o._cons	0 (0)	-	-	-	-	-	-
Mp	-	0.0600*** (0.0158)	0.118*** (0.0216)	-	-	-	-
Exten	-	0.563 (0.747)	-1.349 (0.982)	-	-	-	-
Mi	-	-0.142 (0.784)	1.551 (0.993)	-	-	-	-
Tcgp	-	0.0377*** (0.0140)	0.0345** (0.0155)	-	-	-	-
Electric	-	0.441 (0.679)	0.485 (0.911)	-	-	-	-
Land	-	-0.482** (0.211)	-0.298 (0.299)	-	-	-	-
Asset	-	-1.924*** (0.714)	-0.400 (0.924)	-	-	-	-
5.pgc	-	-0.512 (0.779)	-0.730 (1.102)	-	-	-	-
6.pgc	-	-1.658** (0.782)	0.246 (0.977)	-	-	-	-
1.dcmc	-	-3.477*** (1.232)	0.478 (1.416)	-	-	-	-
2.dcmc	-	-1.668* (0.915)	-1.507 (1.039)	-	-	-	-
3.dcmc	-	-1.895* (1.053)	-0.698 (1.162)	-	-	-	-
Constant	-	0.807 (1.577)	-6.087*** (2.173)	-	-	-	-
Observations	160	160	160	-	-	-	-

Standard errors in parentheses. \*\*\*p<0.01, \*\*p<0.05, \*p<0.1. Iteration 0: log likelihood = -163.34231; Iteration 1: log likelihood = -103.36871; Iteration 2: log likelihood = -97.459321; Iteration 3: log likelihood = -97.170674; Iteration 4: log likelihood = -97.169981; Iteration 5: log likelihood = -97.169981; Multinomial logistic regression, Number of obs = 160; LR chi<sup>2</sup> (24) = 132.34; Prob > chi<sup>2</sup> = 0.0000; Log likelihood = -97.169981 Pseudo R<sup>2</sup> = 0.4051.

Source: Own Survey Data (2017).

is, a model with no predictors). LR Chi<sup>2</sup> (24) is the Likelihood Ratio (LR) Chi<sup>2</sup>. The number in the parentheses indicates the degrees of freedom of the Chi<sup>2</sup> distribution used to test the LR Chi<sup>2</sup> statistic and is defined by the number of models estimated (2) times the number of predictors in the model. The LR Chi-Square statistic can be calculated by  $-2 \times (L(\text{null model}) - L(\text{fitted model})) = -2 \times ((-163.34) - (-97.17)) = 132.34$ , where  $L(\text{null model})$  is from the log likelihood with just the response variable in the model (Iteration 0) and  $L(\text{fitted model})$  is the log likelihood from the final iteration (assuming the model converged) with all the parameters.

From Table 6 (Household food securities==Food insecure (0\_50) is the base outcome), household food

security is the response variable in the multinomial logistic regression. Underneath household food securities are two replicates of the predictor variables, representing the model that is estimated: Moderately food secured (51\_79) relative to food insecure (0\_50) and food secured (80\_102) relative to food insecure (0\_50). The Coef. and referent group are the estimated multinomial logistic regression coefficients and the referent level, respectively, for the model. An important feature of the multinomial logit model is that it estimates  $k-1$  models, where  $k$  is the number of levels of the outcome variable.

In this instance, stata, by default, set food insecure (0\_50) as the referent group, and therefore estimated a model for moderately food secured (51\_79) relative to

food insecure (0\_50) and food secured (80\_102) relative to food insecure (0\_50). Since the parameter estimates are relative to the referent group, the standard interpretation of the multinomial logit is that for a unit change in the predictor variable, the logit of outcome *m* relative to the referent group is expected to change by its respective parameter estimate (which is in log-odds units) given the variables in the model are held constant.

Based on multinomial logit regression, the result in Table 6 revealed that, household market participation intensity (mp) was found significant at 1% level on both moderately food secured (51\_79) and food secured (80\_102) household food security levels relative to food insecure (0\_50). Whereas the amount of total crop group production of household (tcgp), access of asset (asset), and high degree of crop market challenges (1.dcmc) were found significant at 1% level on moderately food secured (51\_79) household food security level relative to food insecure (0\_50). Moreover, arable land (land) and beans/groundnuts producing groups of crops were found significant at 10% level on moderately food secured (51\_79) household food security level relative to food insecure (0\_50). While amount of total crop group production of household (tcgp) was found significant at 10% sig. level on food secured (80\_102) household food security levels relative to food insecure (0\_50). In addition, low and medium degree of crop market challenges were found significant at 5% level on moderately food secured (51\_79) household food security level relative to food insecure (0\_50). On the other hand, the multinomial regression result revealed that, cereal producing groups of crops (5.pgc), extension services for the household per year (exten), access of market information (mi) and electric services (electric) were found insignificant on both moderately food secured (51\_79) and food secured (80\_102) household food security levels relative to food insecure (0\_50).

**Household crop market participation intensity (mp):** Market participation is the participation of smallholder households in crop marketing. As clearly verified in Table 6, the multinomial model regression result signified that household market participation has as same as the hypothesized estimation result in Table 2. It is displayed as it has a direct positive effect and statistically significant on food security at 1% level which is the highest significant level. Moreover, in Table 6 within food security levels, household crop market participation intensity signified as it has essential effects on household food security to move out from food insecure status into moderately food insecure and further to food secured status since it is the highest *z* absolute value (Table 6). Therefore, the household crop market participation intensity statistically signified its direct essential positive effects for the household food security improvements of smallholder farmers in Ada'a Wereda.

**Degree of crop market challenges:** This variable is a

categorical variable, high, low and medium degree of crop market challenges are included in this categorical variable which is displayed in Table 6, high degree of crop market challenge was significant at 1% level, while low and medium degree of crop market challenges were significant at 5% level.

**Producing groups of crops (pgc):** This variable is the effect predictor categorical independent variable for the household food security improvement in Ada'a Wereda, the producing groups of crops are roots/tubers, cereals and beans/groundnuts which are the three category of producing groups of crops that were included in this effect predictor variable. The multinomial regression model estimation result signified in Table 6 was the same with the hypothesized estimation result in Table 2; the hypothesized estimation result denoted that household production ratios is in different groups of crop categories on each of their household farm can market a greater share of their output and therefore face lower/none level of food insecurity challenges; then the change in coefficient predictor effect of these producing groups of crops on the household food security increases. But even though this transaction costs related effect predictor categorical independent variable regression result was significant on 5% level in beans/groundnuts producing groups of crops and this effect predictor categorical variable in Table 6 denoted negative relationships with household food security which were not fitted with the hypothesized estimation result in its sign. The hypothesized point of view was on the suggestion that production ratios with enhanced market orientation on each of specific crop categories would cause to increase the likelihood of household crop market participation intensity on these producing groups of crops with time; this in turn improves the household food security. But in Table 6, multinomial regression result of producing groups of crops has signified negative effect predictor on household food security improvement which clearly indicates as better endeavor is still required for Ada'a Wereda's household food security enhancement, the endeavor needed specifically on household crop market participation intensity on this producing groups of crops should be in the intent of supporting for the establishment of reliable and accessible marketing system; because the result verifies as the Wereda's smallholder crop producer farmers crop production is for the purpose of their household consumption not for market participation, this exposes them for unimproved food security and to lead vicious cycle life style.

**Land (Land):** The size of arable land was hypothesized as it would have positive influence on the household food security improvement of smallholder households. As hypothesized, a larger area of arable land helps to reduce transaction costs per unit of output and would positively related to smallholder household food security improvement but in Table 6, the multinomial logit

regression result showed the reverse but statistically significant at 10% level with household food security improvement, which indicates that the size of arable land for smallholders of Ada'a Woreda's households was not larger as hypothesized.

From Table 6, the study use the margins command to calculate the predicted probability of choosing each food security type at each level of household food security holding all other variables in the model at their means. Moreover, the baseline or reference outcome, in this case 0\_50 (food in secured), which indicated that the coefficient is zero for this baseline outcome.

### Econometric estimation

Model specification diagnostic tests of overall model fit, VIF (variance inflation factors test), hettest (hetroskesdacity) and pwcorr (pair wise correlation) has been checked before applying Tobit regression model to estimate the potential effect of each explanatory variables on the dependent variables of the model. The results of these tests have shown that no problems of sever multicollinearity, model specification bias and hetroskesdacity. For Tobit regression model, probability of  $\text{Chi}^2=0.000$  has been considered to check the model goodness of fit (Table 5).

### Diagnostic test result

Richard William's defined heteroskedasticity by considering Wikipedia's meaning stated that, if the error terms do not have constant variance, they are said to be heteroskedastic [Tidbit from Wikipedia: The term means "differing variance" and comes from the Greek "hetero" ('different') and "skedasis" ('dispersion') (Williams, 2015)]. From this, so as to check whether the error terms have constant variance, hettest (hetroskesdacity test) is employed.

As it is known that, Variance Inflation Factor (VIF) and tolerance level (1/VIF) are two important measures of multicollinearity, this test was conducted for Tobit regression model for the second objective. Therefore, VIF (variance inflation factor test), pwcorr (pair wise correlation), hettest (hetroskesdacity test) have been employed before running Tobit regression for the second objective. Whereas pwcorr (pair wise correlation) and ovtest (omitted variable test) tests was applied before running multinomial logit regression to the third objective. After running Tobit regression for the second objective linktest (link test for model specification) and margins (marginal means, predictive margins, marginal effects, and average marginal effects) tests were employed. After running multinomial logit regression, margins (marginal means, predictive margins, marginal effects, and average marginal effects) test were employed. Moreover, for Tobit

regression model probability of prob.  $> \text{Chi}^2=0.000$  was considered to check the model goodness of fit (Table 5). For multinomial logit econometric model regression, the likelihood ratio  $\text{Chi}^2$  of 132.34 which can be calculated from table 6 by  $-2 \times (L(\text{null model}) - L(\text{fitted model})) = -2 \times ((-163.34) - (-97.17)) = 132.34$  with a p-value  $< 0.0001$  which tells us that this multinomial model as a whole fits significantly better than any empty model for this study. From these, both models are signified as statistically significant. Therefore, the indicated regression models on the displayed results of Tables 5 and 6 which were used for the second and third objectives, respectively were fitted well. Variance Inflation Factor (VIF) and tolerance level (1/VIF) are two important measures of multicollinearity problem (Wooldridge, 2009). In addition, the author claimed that, by rule of thumb, VIF value of 10 or tolerance indexes of 0.10 are used as a critical point to indicate serious multicollinearity problem. The minimum, maximum and mean value of VIF values for the second objective was found 1.41, 3.97 and 2.10 respectively. Therefore, there were no severe multicollinearity problems in the second objective. To test the correlation between variables included in the model pair-wise correlation test was run. As general rule, multicollinearity is a problem when the correlation result is above 0.80 and below -0.80 (Stock and Watson, 2007). The coefficients of all variables were found above -0.2824 and below 0.2738 and between -0.2802 and 0.3775 in the second and third objectives.

The marginal effect results after Tobit model regression result in Table 5 and Appendix F denoted that the variables were at their mean values called marginal means and the marginal effect results after multinomial logit regression result in Table 6 which indicated that the effect predictor independent variables were at their mean values which is also called marginal means.

Williams (2014) claimed that, the variable  $\_hat$  should be a statistically significant predictor, since it is the predicted value from the model. So based on Richard Williams concept if the model is properly specified, the linear predicted value squared variable ( $\_hatsq$ ) should have much predictive power except by chance and the linear predicted value variable ( $\_hat$ ) should be a statistically significant predictor, since it is the predicted value from the model. Therefore, the link test results denoted that the Tobit regression model applied for the second objective was the fit model, because the result implied that the variable  $\_hats$  was found significant with p-value of 0.001 on this Tobit model. Whereas the variable  $\_hatsq$  is insignificant in this model with p-value of 0.136 for the Tobit econometric regression model.

### Conclusions

This study explores the effects of crop market participation in improving food security among smallholder

crop producer farmers: in the case of Ada'a Woreda, central Ethiopia and tried to sort out the most influencing factors on household crop market participation intensity on producing crop groups of smallholder crop producer farmers, the effects of smallholders market participation intensity on their food security at the household level and crop market participation situation in the Woreda. To assess crop market situation of crop producer farmers in Ada'a Woreda, simple statistical summary of descriptive statistics was employed and operated. Moreover, to identify factors that affect smallholder's market participation intensity on crop groups and to analyze the effects of crop market participation intensity on household food security improvement, Tobit and multinomial logit econometric regression models were employed, respectively. For this purpose, the study had applied mainly primary data that was collected from 160 household crop producer smallholder farmers of the four kebeles; these kebeles were Yatu, Gice, Gobesaye and Denkaka found under Ada'a Woreda, Central Ethiopia.

The findings of this study on the specific objective one by using simple statistical summary of descriptive statistics revealed that in the household crop market participation situation, the maximum households' crop market participation intensity was found to be 100 and the minimum was 0. Whereas the mean average value of crop market participation intensity was found 39.87. While, the high, low and medium degree/level of household crop market participation challenges mean value were found around 36, 23 and 21%, respectively, only the remaining 20% household crop market participants of smallholder farmers was none or zero degree/level of crop market challenges in Ada'a Woreda from the 160 sampled household respondents. Whereas in the food security situation of the woreda, among the household food security categories, the food insecure (0-50 weighted sum) category/level showed the most frequently occurring household food security situation in Ada'a Woreda and became the reference group for both the description and the regression outcomes. From the 160 sampled household respondents of smallholder crop producer farmers, around 50% were found food insecure (0-50 weighted sum), 31% were found moderately food secured (51-79 weighted sum) and only the remaining 19% were found food secured (80-102 weighted sum) households.

The findings of this study on the specific objective two via Tobit model indicated that there were factors which were affecting household crop market participation intensity of smallholders at different levels. Therefore, high and low degree of crop market challenges and arable land size of the household were identified significant at 1% level and negatively affecting factors. While medium degree of crop market challenges was identified significant at 10% level and negatively affecting factor for household crop market participation intensity. Whereas none degree of crop market challenges were

found significant at 1% level and extension services per year for household were found significant at 5% level and both were identified as positively affecting factors.

The findings of this study on the specific objective three via multinomial logit regression result revealed that, household crop market participation intensity (mp) was found significant at 1% level and showed positive effect on both moderately food secured (51\_79) and food secured (80\_102) household food security levels relative to food insecure (0\_50). Whereas amount of total crop group production of household (tcgp) showed positive effect, access of asset (asset) showed negative effect, and high degree of crop market challenges (1.dcmc) which showed negative effect were found significant at 1% level on moderately food secured (51\_79) household food security category/level relative to food insecure (0\_50). Moreover, arable land size (land) and beans/groundnuts producing groups of crops were found significant at 10% level and showed negative effect on moderately food secured (51\_79) household food security level relative to food insecure (0\_50). While amount of total crop producing group was found significant at 10% level on food secured (80\_102) household food security levels relative to food insecure (0\_50). In addition, low and medium degree of crop market challenges were found significant at 5% level and indicated negative effects on moderately food secured (51\_79) household food security level relative to food insecure (0\_50); these were the results found in Ada'a Woreda.

The originality of this study is that it has assessed crop market situation of crop producer farmers and identified factors affecting crop market participation intensity and then in turn it analyzed the effects of crop market participation on the improvements of crop producer smallholder's household food security in Ada'a Woreda Central Ethiopia, from the perspectives of crop market participation effects on the improvements of household food security; this may create an opportunity for further constructive debate.

## RECOMMENDATIONS

For further household food security improvement understanding, statistically significant factors that are affecting household crop market participation in general, specifically giving attention for negatively affecting factor variables and enhancing positively affecting variables on market participation intensity and reducing negatively affecting effect variables on household food security are needed.

Based on the result and conclusion of this study, these actionable suggestions are forwarded:

(1) Interventions of strategic efforts for the establishment of reliable and accessible marketing system through

adaptable market linking approach are required in Ada'a Woreda for smallholder crop producer farmers. Because, as the findings of this study have shown, even though the household crop market participation intensity on crop groups is highly significant at 1% level and has positive effect for the household food security improvement but the food insecure situation is the most frequently occurring situation in the woreda. This indicates the household crop market participation intensity in the woreda is low and their crop production is for the purpose of household consumption rather than for market. This situation exposes smallholders for unimproved food security and to lead vicious cycle life style. Therefore, interventions are needed to reduce the founded aforementioned high, low and medium degree of crop market participation facing challenges. The intervention should be in the intent of triggering the household crop market participation intensity augmentation specifically on the establishment of reliable and accessible marketing system through adaptable crop market linking approach.

(2) The conclusion, from the study result identified the main factors for household crop market participation intensity on crop groups and also indicated the analyzed effect predictor independent variables on the outcome (dependent) variable of household food security. For those identified factors and analyzed effects, the following actions both in policy and implementation mechanism needs high attention.

(3) Development of market infrastructure, provision on marketing issue based extension services, preferably market linking focused extension services rather than to continue being dependent merely the present crop productivity extension services and marketing incentive to smallholder crop producers and enhancement of institutionalized crop marketing financial and information services, that is, transaction cost reducing intent institution establishments for smallholders, group marketing system enhancements such as establishing involvement opportunity for the majority crop producer households in crop market associations/cooperatives. For the formation of cooperatives using Equb and Edir Ethiopian cultural social associations is worthwhile, establishing farmer to farmer engagements across the woreda as well as across the country to bring best practices is also essential. In general, high attention is needed for crop marketing issue specifically focusing on adaptable crop market linking systems rather than to be dependent merely on crop productivity is highly advisable. Moreover, it is highly worthwhile to focus in the intent of employing reliable and accessible marketing system for those majority smallholders. These are the recommendations based on the study findings, so as to improve the majority crop producer smallholder farmers' household food security via enhanced market participation and commercializing of their producing groups of crops in Ada'a Woreda Central Ethiopia. The researcher believed that this study result can be applied more or less for the

other similar Woredas also.

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## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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